INFORMATION TO USERS

This dissertation was produced from a microfilm copy of the original document. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the original submitted.

The following explanation of techniques is provided to help you understand markings or patterns which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting thru an image and duplicating adjacent pages to insure you complete continuity.

2. When an image on the film is obliterated with a large round black mark, it is an indication that the photographer suspected that the copy may have moved during exposure and thus cause a blurred image. You will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., was part of the material being photographed the photographer followed a definite method in "sectioning" the material. It is customary to begin photoing at the upper left hand corner of a large sheet and to continue photoing from left to right in equal sections with a small overlap. If necessary, sectioning is continued again — beginning below the first row and continuing on until complete.

4. The majority of users indicate that the textual content is of greatest value, however, a somewhat higher quality reproduction could be made from "photographs" if essential to the understanding of the dissertation. Silver prints of "photographs" may be ordered at additional charge by writing the Order Department, giving the catalog number, title, author and specific pages you wish reproduced.

University Microfilms

300 North Zeeb Road
Ann Arbor, Michigan 48106

A Xerox Education Company

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

72-17,151

PAPPAS, Anthony, 1946-
ADAPTIVE BEHAVIOR AND SPECULATIVE PRICE FORMATION.

Yale University, Ph.D., 1971
Economics, theory

University Microfilms, A XEROX Company, Ann Arbor, Michigan

© Copyright by
ANTHONY PAPPAS
1972

THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Adaptive Behavior and Speculative Price Formation

by Anthony Pappas

1971

A Dissertation Presented to the Faculty of the Graduate School of Yale University in Candidacy for the Degree of Doctor of Philosophy

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

PLEASE NOTE:

Some pages may have

indistinct print.

Filmed as received.

University Microfilms, A Xerox Education Company

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Summary

Adaptive Behavior and Speculative Price Formation

by Anthony Pappas

This dissertation explores some questions about stock market efficiency through the construction of an abstract model. Speculative prices are an endogenous variable determined within the framework of the model. Investor behavior is explicitly characterized. The investors adapt to exogenous information emanating from the environment and to the endogenous prices which the model itself generates. The investors engage in trading in a market with specified institutional arrangements for clearing orders.

The model is simulated to see the effect on security prices of different types of investor behavior, different patterns of exogenous shocks from the environment, and different market arrangements. Criteria of market efficiency are developed. These include the variance of security prices, the relative performance of investors, and characteristics associated with each market clearing arrangement. The performance of different model structures with regard to these criteria is ascertained.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Acknowledgement

The author would like to thank his dissertation committee for their assistance and encouragement. Professors William C. Brainard and Henry C. Wallich constituted the committee in early 1968. For the next three and a half years they examined numerous chapter drafts and revisions. Their penetrating questions helped greatly to clarify and focus the author's efforts. Their patience during periods when progress seemed slow is warmly appreciated. Professor Henry G. Grabowski carefully read the dissertation in 1971 and Professor Martin L. Weitzman served on the committee in 1969-70.

During his four years in attendance at Yale University the author received a Graduate Fellowship from the National Science Foundation. The dissertation was completed while the author was an Instructor at the University of Illinois at Urbana-Champaign and the author is grateful to that institution for providing him with an opportunity to carry on his work.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table of Contents

Chapter	Page
1. Speculative Markets and the Economy.	1
Allocation of Capital Resources	
Portfolio Choice	
Speculative Price Formation	
Scope and Purpose of Dissertation	
2. A Brief Survey of the Literature on Stock Market Prices.	14
The Case for the Random Walk Hypothesis	
The Case against the Random Walk Hypothesis	
Investing and the Efficient Market Hypothesis	
Appendix to Chapter 2: Osborne's "The Dynamics of Stock Trading"	
3. On Investor Behavior.	32
Stock Valuation	
Portfolio Selection	
On Adaptive Processes	
Investor "Types" in the Simulation Model	
4. Adjustment and Market Structure.	53
Vernon Smith's Work in Simulated Gaming	
Pooled Clearing	
Buffered Clearing with Specialist	
Appendix to Chapter 4: The Execution of Orders in Stock Markets Around the World	
5. Investor Behavior, Investor Performance, and the Market.	72

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Elements of the Simulation Model

Simulation Runs 1 to 8

Simulation Runs 9 to 13

Simulation Runs 14 to 19

Simulation Runs 20 to 25

Simulation Runs 26 to 29

Summary of Simulation Runs 1 to 29

Supplementary Note : A Correlationist

6. The Stock Market and the Number of Investors. 121

Some Simple Models

Changing the Number of Investors in the Simulation Model

Discussion of Results

7. Equity Finance and the Allocation of Physical Capital in the Simulation Model. 137

Corporate Behavior

Investor Behavior

Market Arrangements for Sale of New Stock

Evaluating Allocational Efficiency

Discussion of Chapter 7

8. Market Structure and Market Performance. 159

The Role of the Specialist on U.S. Exchanges

The Initial Version of a Liquid Specialist Clearing System

Preliminary Simulation Results with Liquid Specialist System

Second Version of a Liquid Specialist System

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Comparison of Market Performance with Different Clearing Arrangements

Investor Performance

A Final Modification

9. Concluding Observations. 192

Investor Behavior

Market Structure

Transactions Costs

Criteria of Market Efficiency

Perspectives on Future Research

Bibliography 208

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 1 : Speculative Markets and the Economy

At the end of 1968 the market value of listed stocks on the New York and American Stock Exchanges was close to $750 billion. Over twenty million individual Americans were shareholders. The securities industry is a highly visible part of the American economy. Fluctuations in the market prices of securities are observed daily and over time prices of individual issues vary widely. These fluctuations mean that the financial wealth of individuals is constantly changing and these changes may affect their real spending and investment decisions.

One wonders, however, whether these fluctuations are due to underlying changes in the economic environment or whether they are largely generated by market forces which, although influenced by economic events, are primarily manifestations of the market's internal reactions and behavior during the process of speculative price formation. There are two major elements of this process: the investors who exchange assets and the markets on which those assets are traded. The investors synthesize the information at their disposal and adapt to new information provided by the environment and the market. The market is designed to bring buyers and sellers together and facilitate the exchange of assets among the investors. The nature of the market arrangements may intimately affect the terms on

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

which these exchanges are made. We shall develop criteria of market efficiency in order to make comparisons among different market structures.

To motivate our discussion and as a way of focussing the analysis, we should keep in mind the broad social functions which the securities markets are designed to serve. First, they assist in the allocation of scarce capital resources to individual firms. Second, they enable individuals to achieve preferred spending and saving patterns over time by investment in financial assets. They offer to individuals assets with different risk-return dimensions so that efficient allocation of risk across investors is possible.

Allocation of Capital Resources

One often states that a properly functioning capital market, of which the stock market is a part, assists in the allocation of capital resources. Yet large corporations obtain most of their capital funds from internal sources -- retained earnings and depreciation. Some corporations issue convertible bonds and these may be tied to stock market performance; but new issues of stock account for less than 5% of the capital funds used by corporations in a year. If firms have been avoiding the stock market as a major source of capital, can the stock market

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

exercise any influence or control on a firm's performance?

Even if firms as a whole obtain a small portion of their funds from the stock market, for a particular firm at a certain point in time, external financing might be very important. It might permit the undertaking of a project of crucial importance for the firm's future. The importance of external financing should be measured at the margin and its significance might be greater than its absolute size would indicate.

Nevertheless, this direct influence is probably small for most firms and one has to look at indirect relationships. It is safe to say that top management of most corporations is concerned with the market performance of a company's stock. Management personnel often have a direct interest in the price of a company's stock. They may be shareholders themselves and part of their remuneration may take the form of stock options.

Insofar as stock prices reflect the prospective earnings and relative efficiency of firms, they serve as a signalling mechanism to management, stockholders, and the public. A sharp and prolonged fall in a company's shares may indicate that management is not operating the company properly.

More fundamentally, the managers of a firm should use the market price of their stock as a guide to making investment decisions. Given that the proper goal of manage-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

ment is to maximize the market value of the firm's shares outstanding, then Modigliani-Miller (28) and other authors have shown that the firm should undertake investment projects if the return will equal or exceed the market capitalization rate for a steady income stream for securities in that risk class.

The stock market may also promote efficiency through the ability of efficient firms to acquire less efficient firms. The shares of a firm with a low rate of return on assets will probably be selling near the book value of the shares. This will make the firm a candidate for acquisition by a more aggressive and efficient firm, especially if the latter can channel the assets of the former into areas of greater profitability.

The terms on which the stock market makes funds available to firms depends on the evaluation of a firm's prospective investment opportunities. If the evaluations are incorrect and over-optimistic, investment will be directed into undesirable projects from the point of view of the whole economy. Investors will realize their mistake and the low marginal efficiency of investment depresses the stock's price. That the problem of incorrect anticipations is not confined to capitalist economies is apparent when the experiences of planned economies are considered. Both the Soviet and Chinese economies have had problems in selecting the most profitable investment projects.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Some preliminary results on the efficiency of utilization of investment funds have produced surprising results. I.M.D. Little (25) conducted a study of 441 large British firms for the period 1951-59. Little wanted to determine whether a firm's retention rate influenced the rate of growth of its earnings. Did firms with a higher plowback rate exhibit a greater growth in earnings? Little found no relationship between retention of earnings and growth. Thus, the rationale often cited by firms for a high retention rate did not seem to apply in this case.

Using American data for the post-war period Baumol, Heim, Malkiel, and Quandt (2) did a more extensive study covering different sources for a firm's investment funds. They found that the rate of return on new equity capital is very much higher than the rate of return on either plowback or new debt. They confirmed their suspicion that "the rate of return would be greatest on those funds whose acquisition process involved the most severe exercise of market discipline." However, their study does not answer the question whether the proper amount of equity finance was being engaged in and whether the equity capital was directed to the firms with the most profitable investment opportunities.

Portfolio Choice

Investment is, in essence, certain present sacrifice for uncertain future benefit. Investment decision under

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

uncertainty involves purchases of assets -- more or less complex claims to present and future income. The asset-preference approach postulates that assets themselves are the desired objects of choice. But assets clearly are not the elemental desired objects; analytically one should realize that the prices of assets are determined by the valuations placed by individuals on the underlying income opportunities to which the assets represent claims.

The securities markets facilitate the exchange of intertemporal claims. Those individuals with adequate current resources seek to provide for consumption in the future by saving and investing. The individuals who are dissaving are giving up claims to future income in order to provide for current consumption. In addition, there are also groups of individuals (firms) with the ability to transform present resources into future income. The capital markets enable them to acquire funds to finance these investment projects.

Given a world of uncertainty, individuals must consider risk in all these decisions. Their willingness to assume risk will be influenced by their psychological make-up and socio-economic factors like their age, wealth, occupation, family responsibilities, and current and future income opportunities.

The Tobin-Markowitz portfolio theory describes how investors should allocate their wealth in several assets.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

In this framework people select assets according to complex risk preference and expectations functions. However, the theory does not tell us how expectations are formed and very little research has been done in this area. Until portfolio theory confronts this problem, there is a danger that it will remain an elegant tautology. When one asks the question why stock prices are what they are, the response is that they are what they are because people think they should be that. Although this roundabout argument is unsatisfying, often it seems to be the easiest explanation.

Speculative Price Formation

There are two major elements in the process of stock price formation: the investors who exchange assets and the markets on which those assets are traded. The decision-making of the investors can be characterized as an adaptive process. A feature of adaptive processes is that they are governed by the flow of information. The investors utilize this information to form expectations about the course of security prices. As an investor observes the prices of securities or acquires new information, he has the option of revising his expectations and acting accordingly.

In the real world we would not expect all investors to behave in the same fashion. The course of security prices should be sensitive to the way investors act. The

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

actions of the investors may affect the current price of the stock and generate a new equilibrium price. Some investors may want to shift from securities to assets with less risk. Other investors may want to shift from securities if their expectations about the future performance of the economy are poor. Other investors may want to liquidate equities in order to increase their current level of consumption. As they seek to put these decisions into effect, they will change the price of a stock and may induce other investors to alter their portfolio holdings. The original exogenous disturbance to equilibrium may induce market-created fluctuations as investors trade among themselves.

The investors will exchange their assets in a market. Since the number of buy orders over a given interval will usually not coincide with the number of sell orders, several different outcomes are possible. The institutional arrangements of the marketplace will then play a significant role in the price formation process. They may affect when trading takes place, the prices at which trades occur, and the volume of trading at those prices. We can develop criteria for judging the performance of different market arrangements.

One characteristic we may want the market to possess is that it not be overly sensitive to temporary imbalances

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

between supply and demand and consequently develop extreme price fluctuations. There are several ways of dealing with this problem: a specialist can be introduced to absorb some of the imbalance, limits may be imposed on permissible price fluctuations, a trading delay may be imposed so that a sufficient number of orders are available. However, some of these institutional arrangements may interfere with other criteria for judging market performance. The imposition of a trading delay will mean that investors cannot instantly liquidate their position, for example.

Scope and Purpose of Dissertation

It is the purpose of this dissertation to explore some questions about market efficiency through the construction of an abstract stock market model. We shall concentrate on the micro aspects of the process. Speculative prices will be an endogenous variable determined within the framework of the model.

A distinctive feature of the model will be the explicit characterization of investor behavior. One way to understand a speculative market is to comprehend the behavior of its constituent elements. For the investors in the model, explicit expectations functions will be formulated, decision rules will be stated, and specific adjustment functions will be used. The investors will engage in trading in a market with specified institutional arrangements. The investors will adapt to exogenous

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

information emanating from the environment and to the endogenous prices which the model itself generates. The confluence of investor orders in the marketplace will generate security prices.

The model will be simulated to see the effect on security prices of different types of investor behavior, different patterns of exogenous shocks from the environment, and different market arrangements. Like its real world counterpart, the stock market will be viewed as a disequilibrium process where investors are constantly adapting to new situations.

For the simulation model we shall construct several investor "types" who incorporate various characteristics of investor behavior. One suspects that security prices are sensitive to the behavioral characteristics of investors -- whether they react to the underlying economic environment or to the course of security prices, the way they place their orders, the frequency with which they enter the market to conduct transactions. In particular we shall ask:

1. What kinds of investor behavior accentuate fluctuations in stock market prices?

2. What effect does changing the number of investors in the marketplace have? Does the relative size of the investors matter?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The institutional arrangements for the clearing of market orders should have an effect on market performance. One would like to know the advantages and disadvantages of one system versus another. Thus, we shall examine:

3. What criteria for market efficiency can one develop and how well do various institutional arrangements meet these criteria? What kinds of trade-offs exist among the qualities we might like an efficient market to have?

4. Do the institutional arrangements of the marketplace have a substantial effect on the course of prices?

5. Does a specialist serve to stabilize prices and reduce price variability? Will a greater proportion of orders be cleared under a specialist system than under some other arrangement?

We shall construct several model structures and ask:

6. Do different "types" of investors consistently perform better and under what conditions does this occur?

7. Do the market-generated fluctuations in the model interfere with the proper flow of equity funds?

Finally, we shall investigate the properties of the simulation model we have constructed and compare it with some aspects of the real world. The simulation procedure will be useful only if we have succeeded in capturing some

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of the crucial elements of real world behavior in our abstract model.

8. Economists maintain that stock market prices in the real world follow a random walk. Given a deterministic model structure, what price patterns are generated by our simulation model? Are they a random walk or is there auto-correlation?

9. Our confidence in the model will be enhanced if our qualitative results are similar for a given model structure. We shall examine this property of the model by seeing how sensitive the model is to a change in the set of exogenous disturbances.

Ideally, and this seems visionary at the moment, one would like to establish an "identification" between price patterns and model structures. This would be esthetically and theoretically pleasing and would have important implications for effecting changes in the actual real world nature of speculative markets. In order to control violent fluctuations in the price of a particular stock, it is desirable to know if these gyrations are caused by abnormal investor expectations, by the peculiarities of the market's organization, or by the concentrated ownership of the stock outstanding. To enhance allocative efficiency one must ascertain whether there is a lack of adequate information or poor investor

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

evaluation of the information available.

The plan of the dissertation is as follows: Chapter 2 reviews previous work on stock price formation. The next two chapters present the theoretical background for the simulation model. Chapter 3 discusses the behavior of investors. Chapter 4 analyzes the adjustment process whereby investors bring desired and actual holdings into line and shows that this adjustment is intimately related with the structure of the market clearing mechanism. Chapter 5 contains the simulation results for the case of pure exchange of assets among investors. The emphasis is on investor performance and inter-person trading. Chapter 6 considers the question whether the number of investors in the market matters and to what extent. In Chapter 7 the model is extended to the case where two corporations resort to equity financing and allocative efficiency is explored. The importance of the institutional arrangements of the marketplace for market performance is examined in Chapter 8. Chapter 9 discusses criteria of market efficiency and presents concluding observations.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 2 : A Brief Survey of the Literature on Stock Market Prices

If we are to construct a simulation model to explore questions about stock market efficiency, we should be familiar with the nature of the stock market process in the real world. In that way we can examine whether our simulated variables generally conform to the patterns of the real world variables. We may be able to identify structural differences for the deviation of our simulation model from real world behavior.

In the simulation model we shall prescribe a deterministic structure for the investors and the market clearing arrangements. Some investors will use earnings information as a basis for investing; others will attempt to find systematic trends in the price series. One suspects that deterministic behavior on the part of investors will produce systematic patterns in the price series. Such a result would not be in accord with the random walk hypothesis concerning stock market prices.

The Case for the Random Walk Hypothesis

A significant contribution of economists to the analysis of stock market prices in the short-run is the random walk hypothesis. If one plots period-to-period changes in stock prices, it is alleged they will resemble

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

a random walk. Thus, the future price move of a stock cannot be predicted utilizing past price data. At any moment in time the market has discounted all available information and prices are at the appropriate level. New information which becomes available is presumed to exert an unanticipated effect on stock market prices. For if anyone could foresee a predictable pattern in new information, prices would adjust to reflect that fact. The random walk hypothesis does not mean that stock market prices are arbitrary and bear no relation to other variables in the economy. The market utilizes the available information set to determine prices; but no one can foretell what new information will be added to that set.

There is a growing accumulation of empirical evidence suggesting that price behavior on the securities exchanges adheres to the random walk hypothesis. Statistical tests have been run on stock market prices to test the random walk hypothesis. A collection of essays in this area is The Random Character of Stock Market Prices edited by Paul H. Cootner(5).

If there are non-random elements in the stock price series, an investment strategy can be based on those deviations from random behavior. In two papers in the Cootner volume Sidney S. Alexander applied various types of filters to see if a profitable investment strategy could be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

devised. Alexander noted, that if stock prices really were a random walk, there is no investment rule which would produce a profit. In a 1961 paper Alexander applied various filters to the daily closing prices of industrial averages on the New York Stock Exchange. Transactions were effected when the closing price was beyond the triggering price set by the filter. However, in computing profits and losses Alexander assumed that transactions were effected at the triggering price. A bias was thereby introduced on each leg of a transaction, buying and selling, equal to the difference between the triggering price and the closing price of the day the triggering price was crossed. Alexander was rightly criticized on this point and after adjusting for this factor he found "...the filters only rarely compare favorably with buy and hold..." Some filters made profits but "The big bold profits...(of the 1961 paper)...must be replaced with rather puny ones."

In their paper in the same volume Granger and Morgenstern used spectral analysis of a stock price index and also confirmed the random walk theory. They also studied the cross-spectra for various types of industry series. It was found that no one index appeared to lag any other. When a stock price series and a series on sales volume were compared, there was no relationship either when using overall figures or those for a particular firm.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

A body of literature shows that mutual funds on the average perform about as well as the market (14,38). If professional portfolio managers who devote time and energy to stock selection can do no better than a policy of random selection, it may be strong evidence that the random walk hypothesis is true. On the other hand, stock prices may be a random walk because the necessary expenditure of time and energy is made by porfolio managers.

The Case Against the Random Walk Hypothesis

Several researchers have sought to find non-randomness in stock market prices. In his paper Paul H. Cootner (5) developed a model based on the existence of professional and non-professional investors. For the non-professionals there is a relatively high cost to them of acquiring relevant information. When they select stocks they are just as likely to be wrong as not. The professional speculators and investors face a much smaller cost per unit of information acquired. They devote full time to this job, are familiar with the sources of information, and are aware of the relevant variables. They may have some idea of what the price should be. If the price meanders away from this equilibrium the professionals will react to bring it back to its proper level. Small deviations from equilibrium will occur since the professionals may be somewhat uncertain about what the proper price should be, they may take time to adjust their portfolios to take advantage of such deviations, and they may not constantly watch every small market movement in price. However, when

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the deviation is sufficient to cover their opportunity costs, the professionals will enter the market in the hope of making a profit.

The action of the professional investors will set up reflecting barriers at prices above and below the equilibrium price. Since professionals will not have the same expectations and opportunity costs, these barriers will not be rigid. The net result, however, will be that prices will be constrained by these reflecting barriers. Cootner tried to test this hypothesis by trying to detect whether these reflecting barriers existed; but he was handicapped by the lack of a good statistical test of significance.

In the simulation model we shall have investors of varying "type". They shall differ as to their speed of adjustment to certain variables and we shall examine the implications of having certain investor "types" in the model.

Ying (53) found a relationship between price and volume. He used daily prices for Standard and Poor's 500 stock composite index and New York Stock Exchange sales. Three of the propositions in his article are:

1. If the volume of sales has been increasing consecutively for a period of five trading days, then there will be a tendency for the price to rise over the next

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

four trading days.

2. If the volume has been decreasing consecutively for a period of five trading days, then there will be a tendency for the price to fall over the next four trading days.

3. A large increase in volume is usually accompanied by either a large rise in price or a large fall in price.

When Granger and Morgenstern tried to find a relation between prices and volume of sales, they failed to find one. But they used weekly data whereas Ying used daily data. Thus, propositions 1 and 2 from Ying's study do not contradict the Granger-Morgenstern findings. Ying's findings are consistent with a hypothesis that expectations of different investor classes vary and that adjustment to new information does not occur instantaneously. It requires time for the price to adjust as investors shift their portfolios and those who are not persuaded as to the merits of a particular price move are bought out by those who are. Ying's study also differs from other studies in that he classed his observations into various categories and used statistical techniques like analysis of variance which rely on categorical variables, rather than continuous variables. Finally, Ying does not consider the question whether his findings lead one to a viable investment strategy which would be superior to random selection.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

A much more vehement attack on the random walk hypothesis has been made by Robert A. Levy. Most past studies have used a stock market index and applied statistical tests to it. While it is true that one can theoretically "buy the averages", the averages may conceal significant developments or patterns among the individual stocks. Levy (13, 24) applied different investment strategies to the weekly closing prices of 200 New York Stock Exchange stocks during the 260 weeks between October, 1960 and October, 1965. The basic finding upheld the concept of "relative strength continuation", i.e. stocks strong in the recent past are better bets than stocks weak in the recent past. Specifically, Levy found, stocks that were strong during previous periods of twenty-six weeks do far better than other stocks in the subsequent twenty-six week periods; furthermore, there is a close relationship between the degrees of past and future strength over such periods.

Levy's results have been questioned by Michael C. Jensen (19). Jensen points out that the returns on individual securities are related to the overall market rate of return. When the market is rising there are groups of securities that will rise faster than the market. The returns on these securities will be very highly correlated. Thus, a procedure such as Levy's which identifies these rapidly rising stocks will tend to produce

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

a portfolio with high risk. According to Jensen "the success of all the superior models seems to be highly dependent on the selection of a very small number of very successful securities." Jensen also maintains that Levy has not shown that his results are statistically significant. He argues that without tests of significance and an economic theory behind the procedure, we cannot be sure that Levy's purported results will hold in the future or with another body of data. In a Journal of Finance article (24) Levy admits that his evidence is not as strong as it might be: "As a result this study is limited by omission of statistical tests of significance, and omission of measures of return variability among individual securities and individual holding periods."

In a study of mutual funds Sharpe (38) ranked thirty-four funds for the period 1943-53 and 1954-63 according to a reward-to-variability ratio. He found that "an investor selecting one of the seventeen best funds in the first period would have an 11:6 chance of holding one of the seventeen best in the second period." He concluded: "These results show that differences in performance can be predicted, although imperfectly."

When any mutual fund performs better than the market averages, one cannot necessarily attribute this to chance and argue that someone had to be holding the stocks that went up. It is true that ex post some stocks and some

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

funds perform better; but one should determine the probability that a certain portfolio would be drawn ex ante and then see if a fund's performance is statistically significant.

Using data provided by Fundscope (14) we can examine whether some funds consistently perform better than other funds. Fundscope provides information on the performance of 376 mutual funds for annual periods from 1961 to 1968 inclusive. It found that four of the funds did better than the average for the set of 376 funds in seven out of eight years. Using the binomial probability distribution with the probability of success equal to one-half, the probability of getting seven successes in eight tries is equal to

$$\binom{8}{7}\left(\frac{1}{2}\right)^{7}\left(\frac{1}{2}\right) = .0312$$

Thus, with 376 funds in the sample, one would expect by chance alone that 376 x .0312 would do better than average in seven out of eight years. Yet only four funds did better than average -- a disquieting result for the defenders of mutual funds.

However, Fundscope also found that one fund, Enterprise Fund, ranked in the top 10% of all the funds in six of the eight years. Using the binomial distribution with the probability of success equal to .10, the probability of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

getting six successes in eight tries is

$$\binom{8}{6}(.10)^6\ (.90)^2 = 22.68 \times 10^{-6}$$

Thus, there were approximately twenty-three chances in a million that by chance alone, a mutual fund would be in the top 10% for six out of eight years. The fact that this group of 376 funds turned up one fund in that category would lead one to reject the hypothesis that the performance of the Enterprise Fund was attributable to chance alone.

One can argue that the eight-year period was not long enough. Indeed, in 1969 the Enterprise Fund was clobbered in the market decline. Or, one could maintain that the high return on the Enterprise Fund was no more than adequate to compensate for the high risk. Here, one would have to measure the risk in the Enterprise Fund's portfolio and determine whether it was higher than average.

It seems more plausible to argue that, for a time, the managers of the Enterprise Fund did indeed have a superior investment strategy. By diligently seeking "emerging growth stocks" and stocks that were relatively undervalued, they managed to reap high returns. Their prescience and astuteness in pursuing this strategy before it became widely popular no doubt accounts for

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

much of their success. However, as the performance of the fund became known, the fund grew in size -- making the continued application of the strategy difficult. Also, as other managers emulated the Enterprise Fund and sought to invest in undervalued situations, this led to the correct pricing of more securities and the disappearance of extremely profitable investment opportunities.

Investing and the Efficient Market Hypothesis

Using the axioms of geometry one can prove the Pythagorean Theorem and be confident that the result is logically consistent. From the observation that stock market prices are a random walk, attempts have been made to deduce conclusions about investing in stocks. It is often maintained that since prices are a random walk, one can do as well through random selection of stocks. The strictly logical deduction from the observation that prices are a random walk is that investing based on the past series of prices is useless.

The efficient market hypothesis goes beyond the random walk hypothesis and maintains that stock market prices fully reflect available information. If prices have correctly adjusted to all information -- including information on what prices were in the past -- then there seems to be no way to achieve superior performance. The

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

random walk hypothesis is thus seen to be a subset of the efficient market hypothesis.

The empirical work testing the efficient market hypothesis has recently been reviewed by Eugene F. Fama (48). Fama calls statistical tests dealing with the price series "weak form" tests. There are also "semi-strong form" tests, in which the concern is whether prices efficiently adjust to other information that is publicly available (e.g. announcements of annual earnings, stock splits, etc.). Finally, "strong form" tests are concerned with whether given investors or groups have monopolistic access to any information relevant for price formation.

The tests on the efficient market hypothesis thus range from simple statistical tests on the price series, to tests which seek to deal with proximate variables for stock price behavior, to tests concerning particular investor groups in the market. If we believed that the world were perfectly competitive with no barriers to entry and perfect knowledge, then we would expect all investors to earn the competitive rate of return. The efficient market would then be a concomitant of our competitive world. However, we can cite qualifications to show that the world may be non-competitive, if not inefficient:

1. Stocks are priced through the proper discounting

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of future prospects in the market. Based on all relevant information about a company, an equilibrium price is established. However, these equilibrium prices are not immutable. As economic conditions change, the equilibrium level of a stock may also change. Through superior analysis and judgment, some individuals may foresee these changes better. Through their trading activities they will move prices to the new equilibrium level and profit as a result.

Strong-form tests have shown that, by and large, mutual fund managers are not these superior individuals (the aforementioned Enterprise Fund may be an exception). However, there may be another, as yet undiscovered, set of persons that does have this superior ability.

2. The dispersal of information (or, the across-trader variance in receipt time) may be a significant factor. Some investors may devote more time and effort to gathering this information. By being full-time investors, they may be able to act on this information before the public has had time to do so.

One may maintain that the people with superior performance are only being compensated for their effort in seeking and evaluating information. With no barriers to entry one could argue that the returns will be driven down to the level adequate to compensate them for their

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

effort.

3. Some persons may have monopolistic access to information. Specialists and corporate insiders are two examples that come to mind.

4. Until we are convinced that our tests are all inclusive, we cannot give a proof that the market is efficient. Someone may find a heretofore undiscovered relationship that leads to superior performance. Thus, we can never settle the question until we are willing to accept the statement, to paraphrase John Stuart Mill, "happily there is nothing in the laws of the historical behavior of stock prices which remains for the present or any future writer to clear up; the theory of the subject is complete."

In the dissertation a simulation model is used to explore some questions about market efficiency. One might say that the questions will be approached through the back door. We shall prescribe a deterministic structure for the investors and the market clearing arrangements. This structure will often produce an "inefficient" market; but we shall ask what features of the model can be changed to reduce inefficiency. By understanding what produces "inefficiency", we can better comprehend efficient markets. We shall also be concerned with the degree of deterministic behavior that is consistent with

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

an efficient market. By varying the "types" of investors and their speed of adjustment, we shall examine whether our model produces prices that follow a random walk or that contain systematic patterns.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Appendix to Chapter 2 : Osborne's "The Dynamics of Stock Trading"

The process of stock price formation can be studied by building models which will generate prices as an endogenous variable. If the formation of stock market prices is to be dealt with as a dynamic process, it seems clear that one must consider the time-dependent elements of the process. In his article Osborne (31) considers the basic elements of the process to be the orders which arrive at a stock's trading post. Several types of orders can arrive:

(1) Unrestricted market orders to buy or sell. $N_{MB}(t_i)$ and $N_{MS}(t_i)$ are the number of round lot market orders to buy or sell, respectively, arriving at the trading post at time t_i.

(2) Limit orders to buy (at or below) or sell (at or above) a specified price. $N_{LB}(p_i,t_i)$ and $N_{LS}(p_i,t_i)$ denote the number of round lots in these limit orders arriving at time t_i with limit price p_i.

(3) "on stop" or stop loss orders.

(4) market if touched orders.

(5) orders for stopped stock.

(6) "not held responsible" or discretionary orders.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

From these orders Osborne constructs market order functions. Let us consider just the first two types of orders. Then a gross market order to buy function would be obtained by summing the individual market orders to buy over time.

$$M_{Bgr}(t) = \sum_{t_i=-\infty}^{t_i \leq t} N_{MB}(t_i) = \sum_{t_i \leq t} N_{MB}(t_i)$$

At time t* the market orders to buy which have been executed are

$$M_{Bex}(t) = \sum_{t_i=-\infty}^{t_i = t^* < t} N_{MB}(t_i) = \sum_{t_i \leq t^* < t} N_{MB}(t_i)$$

where t* is the time of the last trade.

The unexecuted market orders to buy at time t are thus

$$M_B(t) = M_{Bgr}(t) - M_{Bex}(t).$$

Similarly, the unexecuted market orders to sell at time t may be represented as $M_S(t)$.

For the limit orders the summations will have to range over the prices as well as over time. Thus, the gross limit orders to buy which come into play for a price p and time t are

$$L_{Bgr}(p,t) = \sum_{p_i=p}^{p_i=+\infty} \sum_{t_i=-\infty}^{t_i \leq t} N_{LB}(p_i,t_i)$$

Limit orders will have been executed for past prices, p*, which equalled or were less than a particular p.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Thus, a limit order to buy will have been executed if the limit buy price p_i equalled or exceeded a past price p^*. If we consider all the past prices, we shall get the limit orders which have been executed, or

$$L_{Bex}(p,t) = \sum_{p^* \leq p} \sum_{p_i \geq p^*} \sum_{t_i \leq t^*} N_{LB}(p_i,t_i)$$

The unexecuted limit orders to buy are

$$L_B(p,t) = L_{Bgr}(p,t) - L_{Bex}(p,t).$$

Similarly, the unexecuted limit orders to sell are $L_S(p,t)$.

For trading to occur at time t at price p', it is necessary that

$$0 = M_B(t) - M_S(t) + L_B(p'(t),t) - L_S(p'(t),t).$$

Osborne then proceeds to difference this equation. One can examine the resulting difference equation to determine the nature of the solution. The signs of certain partial derivatives can be investigated. The functions must be specified further and Osborne arbitrarily makes some of the functions linear in price and time.

However, the Osborne article is unsatisfactory because the functions are arbitrary. One would ideally like to see them derived from assumptions about investor behavior. In addition, the functions would change over time as a consequence of inter-person trading and adjustment to the prices which the system generates.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 3 : On Investor Behavior

An essential element of our simulation model will be the characterization of the investors in the model. We must indicate how they will behave as part of the stock market process. In the first part of this chapter the valuation of securities will be discussed. Then, we shall turn to the Tobin-Markowitz theory of portfolio selection. Adaptive processes and the role of new information will be discussed in the third section. And in the fourth section the particular investor "types" in the simulation model will be described.

Stock Valuation

This section of Chapter 3 will review the work that has been done in relating investment opportunities, equity financing, and stock valuation. This section relies on Myron J. Gordon's The Investment, Financing and Valuation of the Corporation (15), and Eugene M. Lerner and Willard T. Carleton's "The Integration of Capital Budgeting and Stock Valuation."(21)

The value of a corporation's share should presumably be the present discounted value of the returns to be realized from ownership of that share. Thus, one has to decide what the returns are and how they vary over time, the investor time horizon for which returns are to be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

considered, and the rate at which returns are to be discounted. In Gordon's model the returns are the stream of dividends, the horizon is infinite, and there is a discount function of various form.

To take a simple example, let the dividend per share in period t be D_t. Then, if the dividend stream is a constant, say $D_t=D$, and the discount rate is k, the present price, P_o of the stock should be

$$P_o = \sum_{t=0}^{\infty} \frac{D_t}{(1-k)^t} = \frac{D}{k}$$

If the dividend stream grows at the rate g, so that $D_t = D_o(1+g)^t$, then $P_o = \frac{D_o}{k-g}$. The assumption that dividends grow at a constant rate derives from two assumed expectations: the corporation earns a constant rate of return, r, on assets; and second, the corporation retains a constant fraction, b, of its earnings. If there is no debt in the capital structure and no equity financing, all growth of future dividends must come via retained earnings. If Y_t stands for the corporation's income and A_t for the corporation's total assets, we have the following relations

$$Y_t = rA_t$$
$$D_t = (1-b)Y_t .$$

Assets increase due to retained earnings, so

$$A_t = A_{t-1} + bY_{t-1} = A_{t-1} + rbA_{t-1} = (1+rb)A_{t-1} .$$

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Thus, assets, earnings, and dividends grow at the rate rb. We can write

$$P_o = \frac{(1-b)Y_o}{k-rb}$$

or, equivalently, $P_o = \frac{(1-b)rA_o}{k-rb}$.

One should note that r and b are the investors' estimates of what the corporation will earn and retain in future periods. Also, there are no subscripts on r and b. In the real world, of course, r and b will change over time. k, the rate of discount investors require on the share, also may change over time. In particular, k may not be independent of r and b.

The above equation enables one to approach the question of the optimum retention rate. If r, k, and Y_o are assumed independent of b, we can take the partial derivative of P_o with respect to b.

$$\frac{\partial P_o}{\partial b} = \frac{(k - rb)(-Y_o) - (1-b)Y_o(-r)}{(k - rb)^2} = \frac{Y_o(r-k)}{(k-rb)^2}$$

The first derivative is zero when r, the average rate of return on assets, is equal to k, the market rate of discount. However, a necessary condition for a maximum P_o is that the second derivative be negative at the value for which the first derivative is zero. If one takes the second derivative, at the value r=k, it is clear that the second derivative is zero. The conclusion

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

is that when r=k, the price of the share is independent of the retention rate. Investors are indifferent if the corporation retains and invests a higher proportion of earnings or pays them out in dividends. When the value r=k is substituted in the valuation equation, the result is

$$P_o = \frac{(1 - b)Y_o}{k - kb} = \frac{Y_o}{k}$$

Returning to the equation for the partial derivative of P_o with respect to b, it is seen that the price increases with the retention rate if r is greater than k, and the price falls with the retention rate if r is less than k.

With r constant and greater than k, the price of the stock exceeds the asset value per share and the stock price increases with a rise in the retention rate. On the other hand, if k is greater than r, the stock price will be less than book value and a rise in the retention rate will lead to a fall in the price. These relations can be illustrated by writing the valuation equation in the form

$$r = \frac{P_o k}{b(P_o - A_o) - A_o}$$

Then, for constant k, one can trace the relationship among b, r, and P.(see Figure 3-1)

Iso-price lines are traced on a graph where r and b are the axes. For a given retention rate, the price is higher for higher internal rates of return which the firm can realize. Thus P_2 is greater than P_1 and both are

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

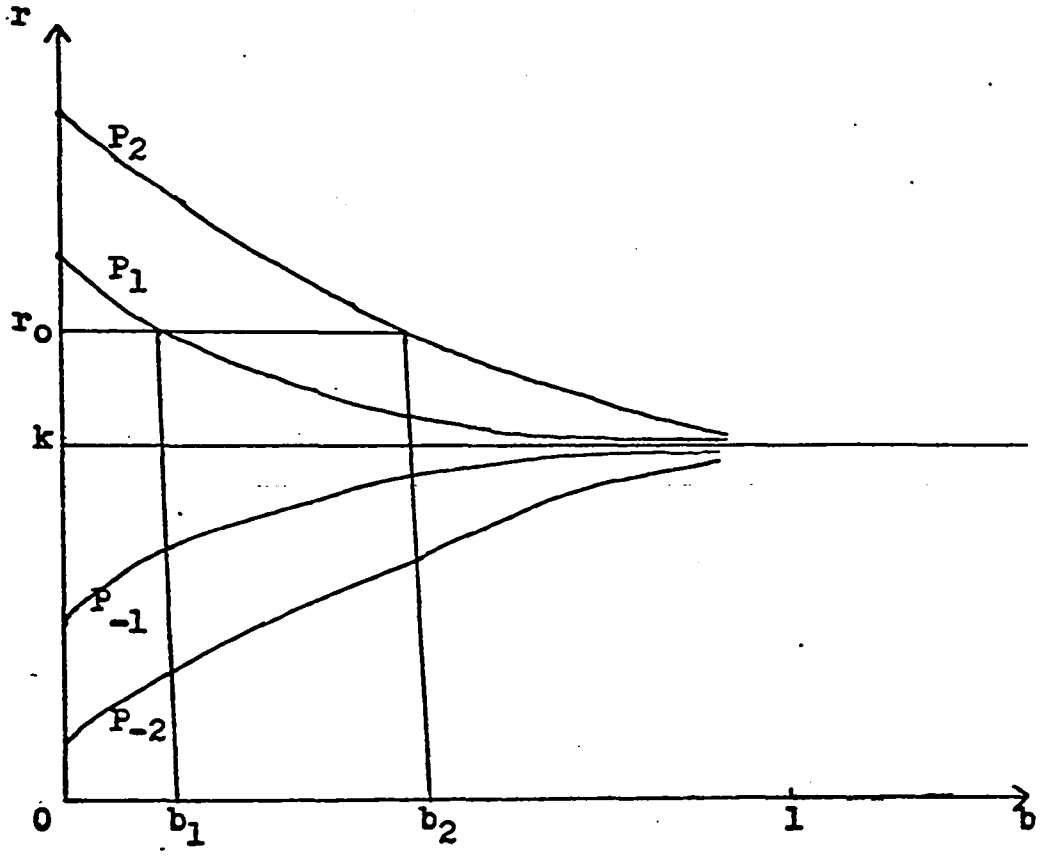


Figure 3-1

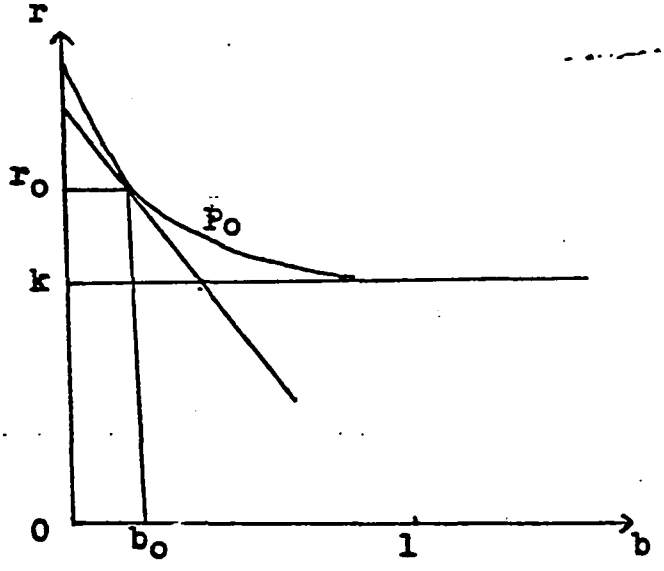


Figure 3-2

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

greater than A. P_{-1} is higher than P_{-2} and both are less than A.

Figure 3-1 shows the relation between P, r, and b. It is assumed that the firm will try to maximize P. If there is no internal constraint on the firm, P is indeterminate. The obvious constraint on the firm will be its ability to achieve high rates of return. Lerner and Carleton posit a constraint of the form r is a decreasing linear function of b. If the firm increases its retention rate, it must invest in projects that have lower rates of return. Of course, the operational form of the constraint involves management expectations of what the relation between r and b is. These expectations may turn out to be incorrect and they may differ from investor expectations.

Given this constraint, Figure 3-2 shows that the highest price is obtained where the investment-opportunities constraint is tangent to an iso-price line. Thus, if b is the firm's decision variable, this method allows us to determine a retention rate that will maximize share price. Notice that r is greater than k at the tangency position.

* * * * *

So far, we have assumed there is no outside financing. Since we are dealing with the stock market, a summary of the present theory on equity financing would be useful.

The existing theory on equity financing seems to be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

at an elementary level. Of course, the standard textbooks on business finance discuss the merits of equity financing vs. borrowing vs. retention of earnings; and the various instruments which can be used: stock warrants, convertible debentures, or preferred stock, to name a few.

The main proposition of existing theory is as follows: If the earnings yield on a stock is s, and if the corporation's rate of return on new investment is greater than s, issuance of new stock will raise the price of the stock. Conversely, if new capital investment has a return less than s, issuance of new stock will depress the price of the stock. This conclusion assumes that the dividend rate has no influence on the valuation of the share. Also, it assumes that the new investors brought into the market with the stock issue will require the same earnings yield as the old investors. Finally, it disregards underwriting costs.

The proposition can be illustrated in a simple case taken from Gordon(15). Assume the corporation pays out all its earnings in dividends and it is planning just a single issue of new stock. If the corporation has one share, if earnings are Y and the market discount function is k, the price of the share will be Y/k. If the corporation raises Q dollars through a stock issue and invests it at a rate r, then earnings in every subsequent

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

period will rise by Qr. But the new investors will only require an income of Qk per period. Hence, the old investors will be getting an income of Y+Q(r-k) and they will bid up the price of the stock to $\frac{Y+Q(r-k)}{k}$ as soon as the stock issue is announced by the company. To raise Q dollars at this price, the additional shares, n, which have to be sold are $\frac{Qk}{Y+Q(r-k)}$. The company now has 1+n shares outstanding. It is easy to see that the yield to the new shareowners will be k. The new earnings of the company will be Y+rQ. The new owners will be getting n/(1+n) of the earnings in dividends. To get the rate then, dividends must be divided by their investment of Q dollars, so

$$\frac{\frac{n}{1+n}(Y+rQ)}{Q} = \frac{\frac{Qk}{(Y+Q(r-k))}(Y+rQ)}{1+\frac{Qk}{Y+Q(r-k)}} = \frac{Qk}{(Y+Qr-Qk+Qk)}\frac{(Y+rQ)}{Q}$$

$$= \frac{Qk}{(Y+rQ)}\frac{(Y+rQ)}{Q} = k$$

Gordon goes on to examine the more interesting case where the corporation is expected to undertake equity financing at a continuous rate over time. We shall not assume that earnings are all paid out in dividends. The stock valuation equation should reflect the equity increment that shareholders expect from the issuance of new shares.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Proceeding formally, if A_t are assets at time t, let the money raised by stock issues Q_t, be a constant, q, of A_t. Or, $Q_t = qA_t$. Then the corporation's assets in period t+1 will be $A_{t+1} = A_t + rbA_t + qA_t = A_t(1 + rb + q)$.

But the equity of existing shareholders will not grow at that rate. Let v be the fraction of Q, the stock issue, that accrues to the stockholders at the end of t. Then, the equity of existing shareholders will be

$$E_{t+1} = E_t (1 + rb + vq) .$$

Earnings and dividends to shareholders will grow at that rate, so $P_t = \frac{(1-b)Y_t}{k-rb-vq}$. The rate of growth of the dividend is raised from rb to rb+vq. To relate v to the other variables we assume the new issue to be sold at the market price of the stock. The dividend expectation of the new shareholders should have a present value equal to the value of the stock they subscribe to.

Thus, if Q_τ is the dollar amount invested at time $t = \tau$, the new investor will have an equity portion in the corporation of $(1-v)Q_\tau$. The dividends will be $(1-b)r(1-v)Q_\tau$ and they should grow at the rate rb+vq.

So, $$Q_\tau = \frac{(1-b)r(1-v)Q_\tau}{k-rb-vq} .$$

Solving, $$v = \frac{r - k}{r-rb-q} .$$

The analysis in this section has been cast in a framework where there is perfect certainty about the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

earnings flow associated with shares in that firm. In the next section we shall assume the returns are uncertain and consider the problem of portfolio selection for an individual investor.

Portfolio Selection

Investor behavior can be analyzed in a risk-return framework. The investor has a utility function which depends on the rate of return he realizes on his wealth. The function can be of the form $U = R + bR^2$, where U stands for utility, R is rate of return and b is a constant. In a world of uncertainty the investor wants to maximize expected utility. Thus, $E(U) = E(R) + bE(R^2)$, where $E(\ )$ denotes the expected value of a variable. This becomes $E(U) = E(R) + bE^2(R) + b\sigma_R^2$, where σ_R^2 is the expected variance in the rate of return. If a_i is fraction of wealth invested in asset i,

μ_i is expected rate of return on asset i,

v_{ii} is expected variance of return of asset i,

v_{ij} is expected covariance of return of assets i and j,

$$E(R) = \sum a_i \mu_i$$

$$\sigma_R^2 = \sum a_i^2 v_{ii} + 2 \sum_{i \neq j} a_i a_j v_{ij}$$

where $\sum a_i = 1$.

It is assumed that the assets have finite variance. For a risk-averse investor b is taken to be negative. It

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

is then possible to solve for the proportion of his wealth, a_i, which the investor should put in each asset.

One should be aware that the characterization of investors as seeking to maximize utility functions quadratic in the rate of return is quite arbitrary. There are other plausible functions besides quadratic functions. In certain cases investors may be concerned with the third moments in the rate of return. Strictly speaking, there may be some objection to extending the quadratic utility analysis to a multiperiod problem. The formulation of the decision problem in terms of the rate of return obscures the importance of the absolute size of the portfolio, which may be a crucial variable. The utility of an investor may be a function of the expected income from his asset holdings. This would in turn depend both on the rate of return and the absolute size of the portfolio. For purposes of the simulation model we shall, however, use only quadratic functions in the rate of return.

In a two-asset world, for example, the investor wants to maximize

$$a_1\mu_1 + a_2\mu_2 + b(a_1\mu_1 + a_2\mu_2)^2 + b(a_1^2v_{11} + 2a_1a_2v_{12} + a_2^2v_{22})$$

If the second asset is a riskless asset with a positive rate of return which is constant, we have that $v_{22} = 0$ and $v_{12} = 0$. The problem is now to maximize

$$a_1\mu_1 + a_2\mu_2 + b(a_1\mu_1 + a_2\mu_2)^2 + ba_1^2v_{11} .$$

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Setting $a_2 = 1-a_1$, we get

$$a_1\mu_1+(1-a_1)\mu_2 +ba_1^2\mu_1^2 +2ba_1(1-a_1)\mu_1\mu_2+b(1-a_1)^2\mu_2^2 +ba_1^2v_{11} .$$

Taking the derivative with respect to a_1 and setting it equal to zero,

$$\mu_1-\mu_2+2ba_1\mu_1^2+2b\mu_1\mu_2-4ba_1\mu_1\mu_2 +2b(1-a_1)(-1)\mu_2^2 -2ba_1v_{11}=0 .$$

Remembering that for a risk-averse investor b is negative, one gets for the proportion of the wealth that should be invested in the first asset:

$$a_1 = \frac{\mu_1-\mu_2 +2b(\mu_1\mu_2-\mu_2^2)}{-2b\left[(\mu_1-\mu_2)^2 + v_{11}\right]}$$

On Adaptive Processes

Most economic decision-making can be characterized as an adaptive process. A feature of adaptive processes is that they are governed by the flow of information. In the real world people make decisions without full information or full knowledge of the parameters which are relevant to the problem at hand. By observing the consequences of their decisions and by the experience gained in dealing with an economic process, decision-makers may improve their performance as time progresses. However, the uncertain environment in which a decision is made means that, at each point in time, several outcomes are possible. Once a decision is made and executed, the characteristic irreversibility of adaptive processes means there is no

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

recourse except to make a new decision in the new situation.

Adaptive processes are part of a wider class of processes known as discrete sequential processes. Before the brief consideration of these processes, the definition of terms for the general process is helpful.

(i) Stage. A discrete process is defined on a set of real integers usually called the stages of the process.

(ii) State. At each stage the variable or set of variables which characterize the process are known as state variables. Where the relation between the stage and the values of the state variables is single-valued, we say the process is deterministic. Where the relation is multi-valued, the process is stochastic.

The state variables of the system may be endogenous or exogenous. The endogenous variables are affected by the process, while the exogenous variables determine the environment in which the process operates at any point of time.

(iii) Decision. The decision variables are those quantities that can be controlled or chosen at each stage.

(iv) Constraints. In many cases the state and decision variables must satisfy certain restrictions. Often, these restrictions are determined by the environment in which the process is operating.

(v) Transition. The function which determines what

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the state of a process will be at a given stage is known as the transition function. The transition function may depend on past state vectors of the process, the state vectors of "environmental" or exogenous processes, and the decision vectors.

(vi) Objective. If the decision-maker is to resolve his problem, he must have a basis for evaluating the possible alternatives. This criterion will be called the objective function.

To fix these ideas, some examples of sequential processes follow.

Descriptive Processes (Type 0 processes)

In a descriptive process the state of the system at time t+1 depends only on the previous state vector and the environment vector at time t. The state of the process at t+1 becomes the previous state for the next stage of the process, and so on.

Sequential Decision Processes (Type 1 or Feedback Processes)

These processes are generated by a transition function that depends on the a priori state vector, environment vector, and some decision vector. The decision vector is some function of a previous state vector, hence the term "feedback". Deterministic type 1 processes can frequently be reduced to type 0 processes by the solution of an associated difference equation. Stochastic type 1 processes contain environmental vectors that are random variables.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Adaptive Decision Processes (Type 2 processes)

The difference between these processes and type 1 processes is that the decision vector is also a function of a historical information vector. The crucial aspect that makes a stochastic decision process an adaptive decision process is the role of historical information or experience in the formulation of the optimum current decision.

The role of adaptive behavior in speculative asset markets is obvious. Investors in the stock market must constantly revise their expectations and adjust to new situations. These new situations are brought about by information flows from outside the market, like company earnings reports; by information supplied by the market, the price patterns of individual securities; and by the reactions of investors to unfolding developments within a market framework. Surprisingly, little work has been done by economists in the area of incorporating adaptive behavior in a speculative asset model.

Investor "Types" in the Simulation Model

The μ's and v's which investors should use for a risk-return analysis are their expectations of the rate of return and the variance in the rate of return for different assets. If we had information about how investors in the real world form their expectations, we could incorporate this into the structure of the simulation model. Such information could presumably be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

gathered by an extensive effort of field research. We would want to know how particular investors evaluate information about particular securities, how they take account of general economic and political conditions, and how they react to unforeseen developments. Clarkson(4) has studied how a trust officer might select a portfolio but further research is needed.

In the absence of such information about real world investors, we shall construct several plausible investor "types" for the simulation model. In forming these abstract investors we shall try to capture important features of real world investors. There is no requirement that our investors behave rationally, since there is no assurance that real world investors do so. We will try, however, to prescribe "reasonable" or "plausible" behavior.

Suppose that on the basis of the past history of a variable, X, people form an expectation about next period's value, X^e_{t+1} . If one postulates an adjustment in expectation based on the discrepancy emerging between the current value and the expectation for that value, the formation of X^e_{t+1} may be described by

$$X^e_{t+1} - X^e_t = \phi (X_t - X^e_t)$$

or

$$X^e_{t+1} = \phi X_t + (1 - \phi) X^e_t \quad .$$

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

This is equivalent to

$$X^{e}_{t+1} = \sum_{\lambda=0}^{\infty} \varphi (1 - \varphi)^{\lambda} X_{t-\lambda} \quad .$$

This approach, suggested by Koyck, has the advantage that the expectation for a variable depends on a single parameter, φ. This parameter is used to weight all the actual values of that variable which have been observed in the past. This expectation function will be utilized in the simulation model and the Koyck weight will be a characteristic parameter of each investor.

We shall describe four "types" of investors for the simulation: fundamentalists, technicians, destabilizing fundamentalists, and techno-fundamentalists.

Fundamentalists

A fundamentalist will be someone who is concerned with the determination of the "underlying value" of a stock. The "fundamental" approach to investment analysis seeks to determine the "underlying value" of a stock by a consideration of such fundamental factors as the assets of the company, its expected rate of return within the framework of industry conditions and general economic conditions, the balance sheet position of the company, and the ability of its management. Fundamental investors are not concerned with transitory factors which do not affect the stock's underlying value.

For the simulation model we shall posit that fundamentalists use the following formula to compute the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

expected price of a stock for the next period:

$$P^e_{t+1} = r^e_{t+1} A^e_{t+1} M^e_{t+1} ,$$

where P^e_{t+1} is expected price in period t+1;

r^e_{t+1} is expected rate of return in period t+1 on the firm's assets;

A^e_{t+1} is the expected size of the firm's assets in period t+1;

M^e_{t+1} is the expected price-earnings multiple for the stock in period t+1.

In the simulation model r will be a random variable with the disturbances in r being exogenous from the point of view of the model. Given observed values of r in the past the fundamentalist will form his expectation of r using the Koyck expectation function. Let r_t denote the observed value of r in period t. Then,

$$r^e_{t+1} = \varphi r_t + (1 - \varphi) r^e_t .$$

Similarly, if M_t denotes the observed price-earnings multiple,

$$M^e_{t+1} = \phi M_t + (1 - \varphi) M^e_t .$$

Assets of the firm will increase solely from retained earnings. We shall assume that the retention rate, b, is announced and known to the investors. Consequently,

$$A^e_{t+1} = A_t + b r_t A_t .$$

In any period t, the expected rate of return from holding the stock will be the expected change in the price over last period's price plus the expected dividend yield.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

If μ_t^e is the expected rate of return in period t and P_{t-1} is the actual price of the stock in period t-1, then

$$\mu_t^e = \frac{P_t^e - P_{t-1}}{P_{t-1}} + \frac{r_t^e (1-b) A_t^e}{P_{t-1}}$$

In any period t, the actual rate of return is

$$\mu_t = \frac{P_t - P_{t-1}}{P_{t-1}} + \frac{r_t (1-b) A_t}{P_{t-1}}$$

The fundamentalist will utilize the discrepancy between expected and actual rates of return to form the expected variance in the rate of return. Using the Koyck expectation function,

$$var^e(\mu_t) = \phi(\mu_{t-1} - \mu_{t-1}^e)^2 + (1-\phi)var^e(\mu_{t-1})$$

where $var^e(\mu_t)$ is the expected variance in the rate of return for period t.

Technicians

The second investor "type" will be called a technician. Technicians base their strategy on the past pattern of prices. They do not seek to understand what is behind the price movements, but utilize them in their decisions to buy and sell. There can be several rationales for technical analysis: a belief that once a trend is formed it will continue; a belief that sophisticated investors with greater information or "insiders" are behind the movement in price and it is sufficient to follow their lead, as reflected in the stock prices.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

To form his expected rate of return, the technicians in our simulation model will rely solely on the past rates of return which have been observed in the marketplace. The actual rate of return is composed of the actual yield from the change in a stock's price plus the actual dividend yield. For the technician, the expected rate of return will be

$$\mu_t^e = \varphi \mu_{t-1} + (1-\varphi)\mu_{t-1}^e \cdot$$

Using the Koyck expectation function, the technician will form his expected variance of the rate of return. He will, of course, rely on the discrepancy between his expected value and the actual value and use his individual φ parameter.

Techno-Fundamentalist

Some investors in the real world seek to combine fundamental analysis with technical analysis. They base their investment strategy on a consideration of both approaches.

For the simulation model we shall posit that a techno-fundamentalist is a combination of a specific fundamentalist and a specific technician. Then, if μ_F^e is the expected return of the fundamentalist, μ_T^e is the expected return of the technician, the expected return of the techno-fundamentalist will be μ_{TF}^e. Specifically,

$$\mu_{TF}^e = \tfrac{1}{2}\mu_T^e + \tfrac{1}{2}\mu_F^e \cdot$$

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The techno-fundamentalist will form his expected variance in the rate of return using the discrepancy between actual and expected values.

Destabilizing Fundamentalist

The fourth investor "type" in the model is what I choose to call a destabilizing fundamentalist. He is exactly like a fundamentalist in the way he forms his expected return and expected variance in the rate of return. However, he will exhibit a paralysis of action until he gets a confirming signal from the market. In other words, his expectations will not become operational until he gets the proper signal. Let us assume his calculations (performed exactly like a fundamentalist) indicate he should have a position in a stock because its expected return is high. The destabilizing fundamentalist will want to be sure the stock is moving upward before buying.

In the simulation model the destabilizing fundamentalist will get a confirming "buy" signal if P_{t-1} is greater than P_{t-4}. He will get a confirming "sell" signal if P_{t-1} is less than P_{t-4}.

One can certainly object to this arbitrary behavior. However, what we need for the simulation model are operational investors who reflect features of the real world. Also, by introducing a destabilizing fundamentalist we can see if he performs better or worse than a fundamentalist who does not utilize signals.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 4 : Adjustment and Market Structure

Once an investor has formed his expectations regarding the rate of return and the variance of return, he can calculate the fraction of his wealth which should be invested in each security. The Tobin-Markowitz formula will give the desired holding of each asset. An investor with a discrepancy between desired and actual holdings tries to remove this discrepancy by some adjustment process.

In the United States when an investor wants to change his holdings in a stock, he usually places an order to buy or sell the required number of shares "at the market". And the order will usually be executed at a price not far from that which prevailed when the order was placed. This is due to the existence of a specialist in the market for a particular stock whose job is to facilitate the execution of transactions. He does this by offering to buy or sell shares of a company's stock for his own account; thus, in effect, becoming a counterpart to a market transaction when another individual buyer or seller is not in the market at a certain point in time. This feature of "making a market" is the central role of the specialist; for it removes the need for an individual investor to wait around until another investor comes along to trade with him.

Nevertheless, it is possible for an investor to reduce some of the uncertainty concerning the price at which

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

his order is executed by placing "limits" on the order. This allows him to specify that an order to buy be executed at a price equal to or less than the limit; and an order to sell at a price equal to or greater than the limit. However, the investor runs the risk that a limit order will not be executed, since the market price may stay away from the limit price.

There are other markets which do not have a specialist who "makes a market." Classical price theory envisions transactions between buyers and sellers taking place according to a tâtonnement process. Someone calls out a price and buyers and sellers announce their demand and supply at that price. If excess demand is negative, the price is lowered. If it is positive, the price is raised until excess demand is zero. In other markets haggling and bargaining occur among the participants until a satisfactory price is arranged. Commodity markets do not have specialists. An order can be executed only if there is another individual willing to be the counterpart in a transaction. Yet, commodity markets sometimes adopt restrictions on their operations. They may limit the allowable change in a commodity's price from day to day. Then, for example, if the price of silver rises from $1.95 to $2.05, which would be the permissible change with a 10¢ limit, there will presumably be some unfilled orders to buy at $2.05 at the end of the day. For a discussion of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the trading arrangements of various stock exchanges in the world, see the appendix to this chapter.

Vernon Smith's Work in Simulated Gaming

Some researchers have studied price behavior in markets by placing individuals in a market environment. This kind of simulated gaming is becoming popular and one of these games will be briefly described (from Vernon L. Smith's "An Experimental Study of Competitive Market Behavior")(41).

Each buyer receives a card containing a number, known only to that buyer, which represents the maximum price he is willing to pay for one unit of a commodity. Each buyer makes a profit equal to the difference between his actual contract price and the maximum reservation price on his card. Each seller receives a card containing a number, known only to that seller, which represents the minimum price at which he is willing to relinquish one unit of the commodity. The seller's profit is equal to the difference between his actual contract price and the price on his card. When the trading period opens, each participant can cry out the terms on which he is willing to trade. This offer may be accepted by one of the participants or a new offer made. When a transaction is consumated, the price is recorded and the participants in the trade are enjoined from further trading in the market until the next trading period. Trading is conducted for a

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

specified length of time, whereupon the current period ends and a new period begins. Smith keeps the experimental conditions of supply and demand constant over successive trading periods in order to give any equilibrating mechanism an opportunity to establish an equilibrium over time.

The cards define a demand and supply schedule for the commodity in question (see Figure 4-1). These schedules do nothing beyond setting extreme limits to the observable price-quantity behavior in that market. Competitive price theory asserts that there will be a tendency for price-quantity equilibrium to occur at the extreme quantity point of the intersection of the two schedules and Vernon L. Smith examines this proposition. The experiments are carried out for various kinds of supply and demand schedules.

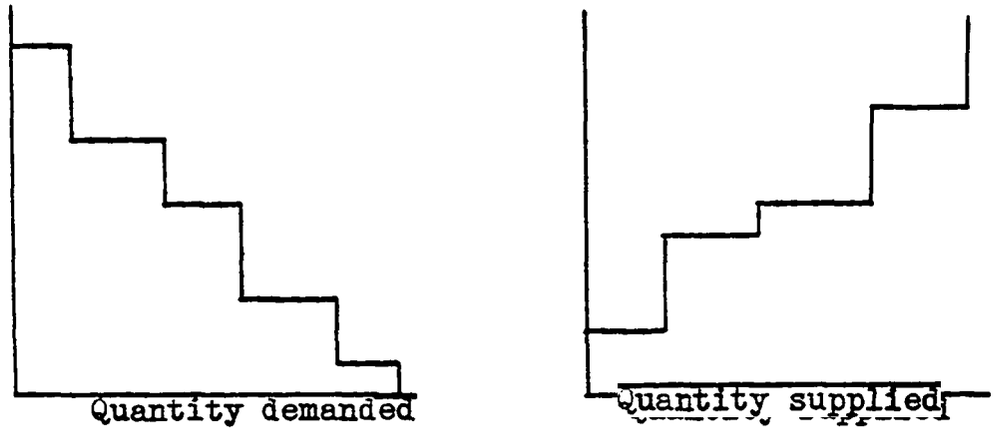


Figure 4-1.

* * * * *

For the adjustment process in the simulation model, we must describe the market structure in which investors

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

find themselves. If the model is to be simulated, specific rules for the participants must be established which determine their market behavior. Without real individuals playing a game, it is not feasible to have someone "call out an offer" to see if it will be accepted. Also, it would be difficult to structure market behavior to reflect bargaining strategies or haggling among investors who are aware of each other's presence in the market.

The problem facing an investor may be illustrated by considering the Fundamentalist. At the end of period t, say, given that the price of the stock was P_t, he will have an excess demand function for the security in question. Given the Fundamentalist's assessment of the prospects for the stock, he would need some additional shares of the stock in order to be in an equilibrium position. But when he places an order for these additional shares, he is not certain what the price of the stock will be in period t+1. The number of shares he would like to purchase in period t+1 is not invariant with respect to the price. In general, the excess demand function for the Fundamentalist will have the usual negative slope (see Figure 4-2.). As the price in period t+1 rises he would want fewer additional shares for two reasons : the expected gain would be smaller; the rise in the price ipso facto increases the value of the shares he held as a proportion of his total wealth. If P_{t+1} were even higher, the Fundamentalist's excess demand

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

would be negative. If P_{t-1} were less than P_t, the Fundamentalist might want to purchase even more shares: the expected gain would be greater and the shares already in his portfolio are worth less.

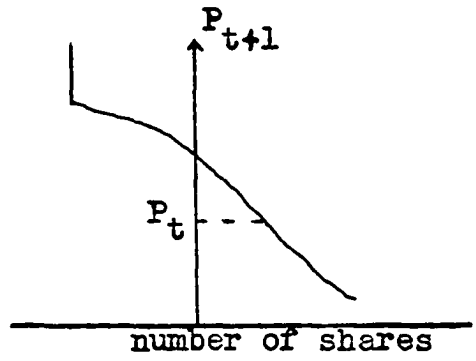


Figure 4-2. Excess demand function for a Fundamentalist.

In the simulation model we will allow the investors to place orders to buy or sell a certain number of shares. Three clearing systems will be specified: pooled clearing; buffered clearing with a specialist; and liquid clearing with a specialist. The liquid clearing system will be discussed at length in Chapter 8. At this point only the pooled clearing and buffered clearing systems will be described, since they shall be used in the next three chapters.

Pooled Clearing

In the pooled clearing system there will be no specialist. Rather, the orders will arrive at a "black box" and be executed according to prescribed rules. We shall allow investors in the pooled clearing system to place

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"limit" orders only. Orders can be placed at the beginning of each trading period. If we cumulate all the buy orders and all the sell orders separately, we shall get market demand and supply schedules like the ones referred to in connection with V. L. Smith's experiments. We shall have the black box find the extreme quantity point where the two schedules intersect. This will determine the period's price and the limit orders which are executed.

Several ambiguous situations may arise. Consider the case in Figure 4-3 where the two functions coincide along a "rise" in the step function. In this case the midpoint of the "rise" will be picked as the market price for that period.

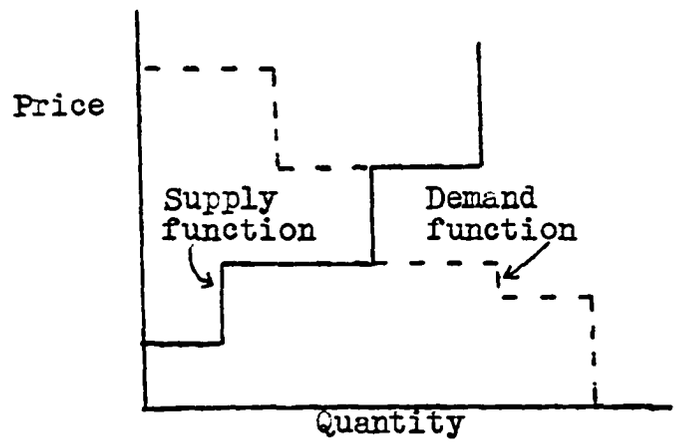


Figure 4-3.

Another problem arises where, at the market price, there is an imbalance between supply and demand. In Figure 4-4 the supply function intersects the demand function at price P_t, but the quantity supplied exceeds the quantity demanded.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Since we are dealing with step functions this would be a common occurrence. In Figure 4-5 the market functions coincide along the "flat" part of a step for part of the way; but at that price the quantity demanded exceeds the quantity supplied. Although the total imbalance may be small in both cases, supply and demand will be brought into balance by prorating among the investors.

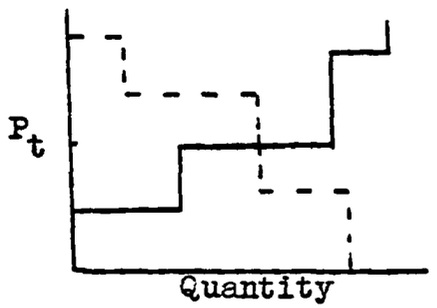


Figure 4-4

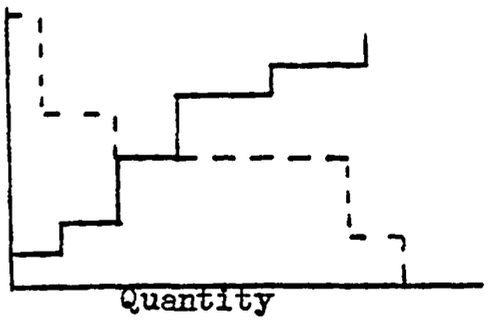


Figure 4-5

Finally, where there are only buy "limit" orders and no sell orders, the market price for that period will be the highest bid price. Where there are only sell "limit" orders and no buy orders, the market price will be the lowest asked price. No transactions can take place in such instances; but a market price will be determined. With a small number of investors it will not be unusual to find that they are all on the same side of the market in a particular period.

How will the investors place their limit orders? At the end of period t-1, say, based on his expectations an investor can calculate the desired fraction of his wealth to be held in a security. He will compare the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

desired fraction with the actual fraction. This can be translated into an excess demand or excess supply of so many shares. To be specific, let us assume that the investor wants to dispose of some of the shares for he expects the rate of return on the security to be negative. (Or, the return is so low as compared with other alternatives, that he still wants to sell some shares.) Let S be the number of shares he wants to sell and μ the expected return on the issue. Now the investor cannot be sure the price in period t will be equal to the price in period t-1 and that he will, in fact, be able to sell S shares at the old price. So, we will let the investor place two limit orders, one to sell at the old price or above; and a second limit order to sell at a lower price to increase his chances of selling at least part of his holdings. The two orders will be:

1. sell 3/4 S at limit price of P_{t-1}.
2. sell $\frac{1}{4}$S at limit price of $P_{t-1}(1 + \gamma\mu)$, where $0 < \gamma < 1$.

How about an investor who believes the stock is going up? He will try to buy some shares at a price above the price in period t-1. Specifically, if he wants to increase his holdings of a security by S shares given a positive expected rate of return μ, the two orders he will place will be:

1. buy 3/4 S at limit price of P_{t-1}.
2. buy $\frac{1}{4}$ S at limit price of $P_{t-1}(1 + \gamma\mu)$, where $0 < \gamma < 1$.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Admittedly, this is a crude procedure but some adjustment function has to be specified for an environment where the investors are not certain what the next price in the market will be.

Buffered Clearing with Specialist

In the buffered clearing system there will be a specialist in the market. The investors will not place limit orders. They will calculate the discrepancy between desired and actual holdings and place market orders for the required number of shares. The specialist will gather these market orders for a particular period and add them up. The buy orders and sell orders will usually not be in balance. The specialist will either buy or sell shares for his own account to try to bring about a balance. All transactions will take place at one market price for each period. The specialist will not devote all his resources in an attempt to bring about balance. In each period he will devote only half of the previous period's holdings of either cash or securities. Where balance is not achieved after the specialist's intervention, prorating among the investors will be used. Also, the maximum period-to-period permissible percentage price change will be set at a prescribed level, call it χ.

To be specific, suppose the investors as a group want to sell more shares in a periodthan they want to buy that period. The specialist will take half his cash holdings and determine that at most he can buy R shares.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The following outcomes are possible:

1. specialist buys R shares; there is still excess supply, prorating among investors wishing to sell; $P_t = (1 - \chi)P_{t-1}$.

2. specialist buys $T < R$ shares; balance achieved with specialist's purchase of T shares; total sell orders executed are V; $P_t = (1 - \chi\frac{T}{V})P_{t-1}$.

Analagously, investors as a group may desire to buy more shares than they want to sell. The specialist will sell at most half his previous period's security holdings. Let this number of shares be R. The following outcomes are possible:

1. specialist sells R shares; there is still excess demand; prorating among investors wishing to buy; $P_t = (1+\chi)P_{t-1}$.

2. specialist sells $T < R$ shares; balance achieved with specialist's sale of T shares; total buy orders executed are V; $P_t = (1 + \chi\frac{T}{V})P_{t-1}$.

Thus, the specialist's inventory position is acting as a "buffer" and attempting to clear the market.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Appendix to Chapter 4 : The Execution of Orders in Stock Markets Around the World

Since the most immediate role of a stock exchange is to bring buyers and sellers together to effect transactions, a comparative survey of the order-clearing mechanism used by several exchanges around the world is useful.

Orders to buy and sell shares of a particular issue are executed at designated "posts" on the floor of an exchange. These posts may simply be places where brokers interested in dealing in a certain security can assemble; or they may be staffed by persons who take a part in or oversee the execution of transactions.

The trading floor of the London Stock Exchange is divided into sections for particular types of securities. These sections are called "markets". Thus there is a market for mining stocks, one for oil stocks, another one for gilt-edged bonds, and so on. Within each market there are "pitches" for the jobbing firms that deal in that class of security. Near his pitch a jobber hangs a price list of the issues in which he specializes and remains nearby to accept orders. London Stock Exchange members can be either jobbers or brokers, but not both. A jobber buys and sells stocks for his own account. A jobber deals with brokers and with other jobbers but never with the public. There is competition among the jobbers since a security is

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

handled by more than one jobber. A jobber selects various issues in which he will deal. There is no obligation on him to buy or sell these issues unless and until he announces a bid or asked price. Once a jobber announces a price he is obligated to buy a "reasonable" quantity of the stock at the bid price or to sell a "reasonable" quantity at the ask price. The 3:30 p.m. closing does not mean the end of trading for the day. Members are permitted to execute transactions in their offices or over their telephones at any hour of the day or night.

The Japanese exchanges also have two types of members: regular and saitori members. The former's principal activity consists of buying and selling stocks on the floor of an exchange for customers or for its own account. A saitori's function is to act as an intermediary between regular members in the execution or orders on the floor. Each such member is assigned to a trading post to act as the specialist in certain issues. Specialists on a Japanese stock exchange differ from those on the New York Stock Exchange in that they do not trade for their own account. All orders to buy or sell are delivered to a saitori member who crosses the orders in an impersonal manner to arrive at a fair price.

The Paris Bourse has three methods for arriving at a price for an issue. The "quotation by auction" method is used for the more active issues. Trading is carried out under the auspices of an auctioneer. Each auctioneer

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

oversees the trading in about thirty or more issues. The auctioneer announces that trading will begin in a particular issue. He calls out a price for the issue. The brokers who are assembled contract with each other to deliver or to accept delivery of shares at this price. Usually there will be some unfilled orders at this tentative price. The auctioneer notices this and establishes another tentative price. The previous obligations of the brokers are not altered by this substitution in the tentative price. If the broker contracted to buy 100 shares at a price of 18, he must now pay 19 for those 100 shares. However, brokers may make new contracts at each tentative price. Thus, if the broker's customer is not willing to take the shares at 19, the broker will seek to make a new contract to sell 100 shares. The auctioneer adjusts the tentative price until the market clears. At that point the tentative price becomes official and the auctioneer announces a tentative price for another issue on his list.

The "quotation by opposition" method is used for less active issues. Brokers report to a clerk the price at which they are willing to buy or sell. The clerk enters the price and the name of the brokerage firm. Periodically, an exchange official looks at the clerk's record, notes the brokers willing to trade and the price at which they will buy or sell. He will then ask the brokers how many shares they are willing to buy or sell.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

He utilizes this information to determine a price that will maximize turnover, i.e. he finds the price at which the largest number of shares would be exchanged.

In the "quotation by boxes" method the brokers report on slips of paper the price and number of shares they are willing to trade. The slips are separated by issue, and periodically a price that maximizes the exchange of shares is announced.

The trading day on the Amsterdam Stock Exchange is divided into six ten-minute periods plus a seventh period of fifteen minutes. Quotations of successive trades are not reported as they are in America, and figures on volume are not tabulated. The high and low quotations for each active issue for each of the trading periods are reported on the ticker tape and published later in the official register. Brokers with orders to buy or sell active issues go to the hoek or post for each issue and call out their bids and offers. When they find a counterpart for a transaction, the trade is effected. An exchange official notes the prices of transactions and reports the high and low quotations for each trading period. Inactive issues are handled differently. There is a specialist for each inactive issue who, at the end of the seventh period, arrays the orders which brokers have placed with him during the day. He finds the price which maximizes turnover and that becomes the official price.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Brokers on the Melbourne, Australia stock exchange go to the proper post for a particular issue. They call out their offers. If there is no response, they write down their offers on a board together with their identification numbers. The function of the board is merely to facilitate a meeting of brokers so that they may settle details of a trade by direct negotiation.

Trading procedures on some Latin American exchanges will be briefly described. In Mexico City and Buenos Aires the price-determining mechanism is essentially one of brokers bargaining among themselves in a competitive manner. Some members may concentrate on certain stocks in which they become unofficial, but effective, makers of the market. In Brazil trading is done by the call method. An official calls out the names of issues in order and the brokers proceed to negotiate among themselves. Thus, instead of having transactions in different securities going on simultaneously, they are taken in turn.

The specialist system was given a trial in Toronto a number of years ago. The practice was discontinued when it was found that the specialist served no useful purpose in the Toronto market. Likewise, the exchange does not have a jobber system as exists on the London Stock Exchange.

The price-determining mechanism on each exchange also affects the dissemination of information to the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

public on transactions. Naturally, investors can obtain closing quotations on securities after the markets have closed, but the situation with regards to the reporting of all trading transactions shows wide variations. Besides the potential ability to get such intra-day information, the ease with which such information can be obtained is just as important. It is not adequate to require investors to be physically present at the stock exchange building in order to watch the transactions being posted on blackboards. Nor is the situation satisfactory when investors must spend half an hour trying to get a quote through their brokers. To a large degree the accessibility of information depends on the technical capability of the communications equipment with which each stock exchange is equipped.

Where one person has the responsibility for determining transactions in a particular issue, the prospects for obtaining information are good. Thus, the specialist system on United States exchanges and the saitori system on Japanese exchanges provide for the rapid dissemination of information on transactions. On the London Stock Exchange where many jobbers deal in each issue, the picture is different. Prices at which transactions occur are usually, but not always, reported by the brokers and jobbers. The reporting of prices is not compulsory. There are no figures as to the number of shares traded in

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

a particular security, volume figures being a jealously guarded secret. Most of the banks in France post quotations throughout the day for their customers. A ticker tape network does not exist in France. The exchange does not provide statistics on volume. We have already seen that on the Amsterdam exchange only the high and low quotations are given for each of the seven trading periods during the day. The Toronto stock exchange has an advanced system for providing up-to-the-minute information on market transactions. The degree to which information is available thus varies greatly, even in the more advanced countries of the world. And one also has to consider the less advanced countries with their more informal procedures and less developed communications facilities.

To summarize: The exchanges of the world have different methods for effecting trades and the prices of transactions. These are: the specialist system on U.S. exchanges, where usually one person in each issue has responsibility for crossing transactions and participates in many of the transactions for his own account; the jobber system in London where many jobbers determine transactions and trade for their own accounts; the saitori system in Japan where a specialist crosses transactions but does not trade for his own account; in Paris officials help brokers arrive at a price through an auction method or determine the price through the "quotation by opposition"

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

method; in Amsterdam an official oversees transactions at the hoeks; in Brazil trading is done in order by a call method; in Melbourne and Toronto brokers agree on the price by bargaining among themselves.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 5 : Investor Behavior, Investor Performance, and the Market

The previous chapters outlined the theoretical and technical considerations associated with stock market trading. Now it is time to specify the precise features of a stock market simulation model by giving specific values to the parameters of the model.

Elements of the Simulation Model

There will be two assets in the model : a security on which investors receive dividends; and a riskless asset providing a positive return of 5% a year. (This second asset can be considered a savings deposit, or it can be viewed as cash on which there is a positive rate of return. Although, strictly speaking, it should be referred to as savings deposit, the awkwardness of doing so will usually lead us into calling it simply cash; but the reader should remember that for all the simulation runs it has a positive rate of return.) The simulation will start from an equilibrium position where the investors' expectations are such that they are satisfied to hold the two assets in the proportion that they do. This equilibrium will be disturbed in the first period of the simulation by an exogenous shock that will affect the rate of return on the firm's assets. By this route the firm's

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

earnings will be affected since earnings are the product of the rate of return and the assets of the firm. These shocks will continue to affect the firm's rate of return in every succeeding period of the simulation. Specifically, if r(t) is the firm's rate of return on assets,

$$r(t) = .10 + u(t) ,$$

where u(t) will be a deviate drawn from a table of normally distributed deviates with mean zero and specified variance. Dividends will be a constant fraction, (1-b), of earnings per period, where b is the retention rate. The capitalization of the firm shall consist solely of equity and assets will increase through retained earnings. Each simulation run will consist of 100 periods with each period being conceived as one-fiftieth of a year's time. Both assets pay out a return in every period.

The procedure of having earnings shocks every period is a heuristic device to keep the simulation going. In the real world investors receive earnings reports at about three-month intervals. It would not be possible then to explain day-to-day changes in stock market prices with a model which utilized just quarterly earnings reports. One would have to say that investors are forming earnings expectations all the time; but then other exogenous variables must be introduced. Since we do not have a valuation model which can incorporate these variables -- and they would be such factors as the changing outlook for the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

economy and the firm -- we must resort to heuristic devices to keep the simulation going. In the simulation runs, as the investors revise their expectations on rates of return and variance of return by using the earnings reports and prices of past periods, they shall place orders in the marketplace and these will generate the current period's price.

Simulation Runs 1 to 8

Table 5-1 and Table 5-2 describe the structural characteristics of the first eight simulation runs.

Highlights of Run 1:

	Initial Net Worth	Final Net Worth	Percentage Change
Fund. One	$29850.	40889.5	37.0
Fund. Two	29850.	40554.7	35.9
Tech. One	29850.	24739.5	-17.1
Tech. Two	29850.	29110.9	-2.5
Tech.-Fund.	29850.	36747.3	23.1
Dest.-Fund.	29850.	34408.4	15.3
Total	179100.	206450.3	15.3

At a glance one can see that in Run 1 the two fundamentalists did much better than the two technicians, who both sustained losses. The techno-fundamentalist and the destabilizing fundamentalist achieved intermediate results.

By looking at the diagram for the price series, one

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 5-1: Common Structural Elements of Simulation Runs 1 to 8

Model Parameters

Market clearing system : Pooled clearing

Coefficient of risk preference = 1.5

Number of investors = 6

Adjustment coefficient for investors, $\gamma = .25$

Initial Conditions

Price of share = 199.

Assets/share = 100.

Each investor holds 100 shares of stock and $9950 in savings deposit for an initial net worth of $29850.

Investor Types

1. Fundamentalist One : Koyck weight of 0.1
2. Fundamentalist Two : Koyck weight of 0.05
3. Technician One : Koyck weight of 0.1
4. Technician Two: Koyck weight of 0.4
5. Techno-Fundamentalist : combination of Fundamentalist Two and Technician Two.
6. Destabilizing Fundamentalist : characteristics of Fundamentalist Two. Signals obtained by comparing P_{t-1} with P_{t-4}.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 5-2: Different Structural Elements of Simulation Runs 1 to 8

Run 1 : Retention rate = 0.
$r(t) = .10 + u(t)$, where $u(t)$ drawn from table of normally distributed deviates with mean zero and variance 1/900.

Run 2 : Same as Run 1, except that retention rate = .2

Run 3 : Same as Run 1, except that retention rate = .6

Run 4 : Retention rate = 0.
$r(t) = .10 + u(t)$, where $u(t)$ has mean zero and variance 1/225.

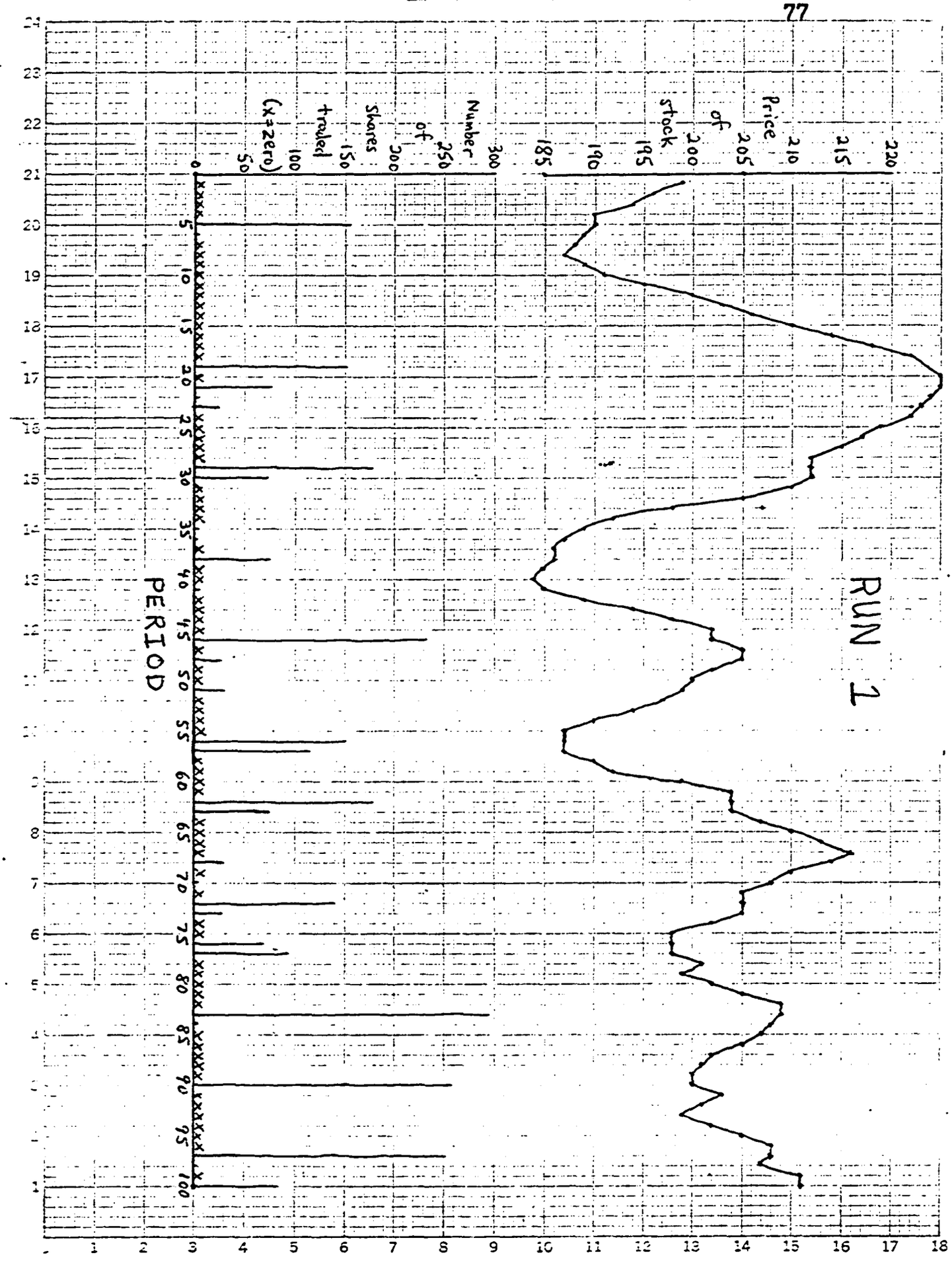
Run 5 : Same as Run 4, except that firm's retention rate = .2

Run 6 : Same as Run 4, except that retention rate = .6

Run 7 : Retention rate = 0.
$r(t) = .10 + u(t) + .0002t$, where $u(t)$ has mean zero and variance 1/900.

Run 8 : Same as Run 7, except that retention rate = .2

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

can see that the price fluctuations were within a narrow range. This should not be surprising if one stops to consider the stabilizing features which are built into the model. Fundamentalists One and Two stand ready to buy when the price is below the underlying value and to sell when it is above it. Because of the Koyck adjustment feature of the technicians' adaptive behavior, they essentially can be characterized by inelastic price expectations in the short-run.

Although it would be instructive to dissect the trading of every period to see which investor executed which transactions, such an endeavor would burden the reader with too many details. One feature of Run 1 is that in most periods no trading took place between investors. Indeed, due to the peculiarity of his decision functions, the destabilizing fundamentalist did not effect any trade during the entire course of Run 1. There was no trading in most of the periods because most investors were on the same side of the market, i.e. they all either wanted to buy the stock or they all wanted to sell the stock. In such cases no trading took place and the price was determined by taking the highest bid price or the lowest asked price of the limit orders to buy and sell, respectively.

A typical illustration of what occurred during Run 1 is the following summary. Good earnings would lead

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the fundamentalists to start bidding the price up. As the technicians realized the price was going up, they would also enter their bids for the stock. When the price exceeded the underlying value, the fundamentalists would unload their holdings onto the technicians. The technicians might carry the price a little higher; but because of their inelastic expectations they would become wary of the stock and start to sell. At this point there would be no buyers in the market and the price would fall for several successive periods until the fundamentalists found the price "cheap" enough to enter the market. At this time there would be a huge trading volume as the technicians sold the bulk of their holdings to the fundamentalists. In such a model, the technicians are usually buying high and selling low and the technician who reacts faster will not do as worse as his slower companion. Thus Technician Two sustained a small loss while Technician One experienced a more severe loss.

If one examines the price differences for successive periods, there will be a high degree of correlation. If $d_t = P_t - P_{t-1}$, then the following regression equation holds:

$$d_t = .079 + .635d_{t-1}.$$

And if one examines the diagram of the price series, one will see the high degree of autocorrelation in Run 1 and one will also observe the intermittent bursts in the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

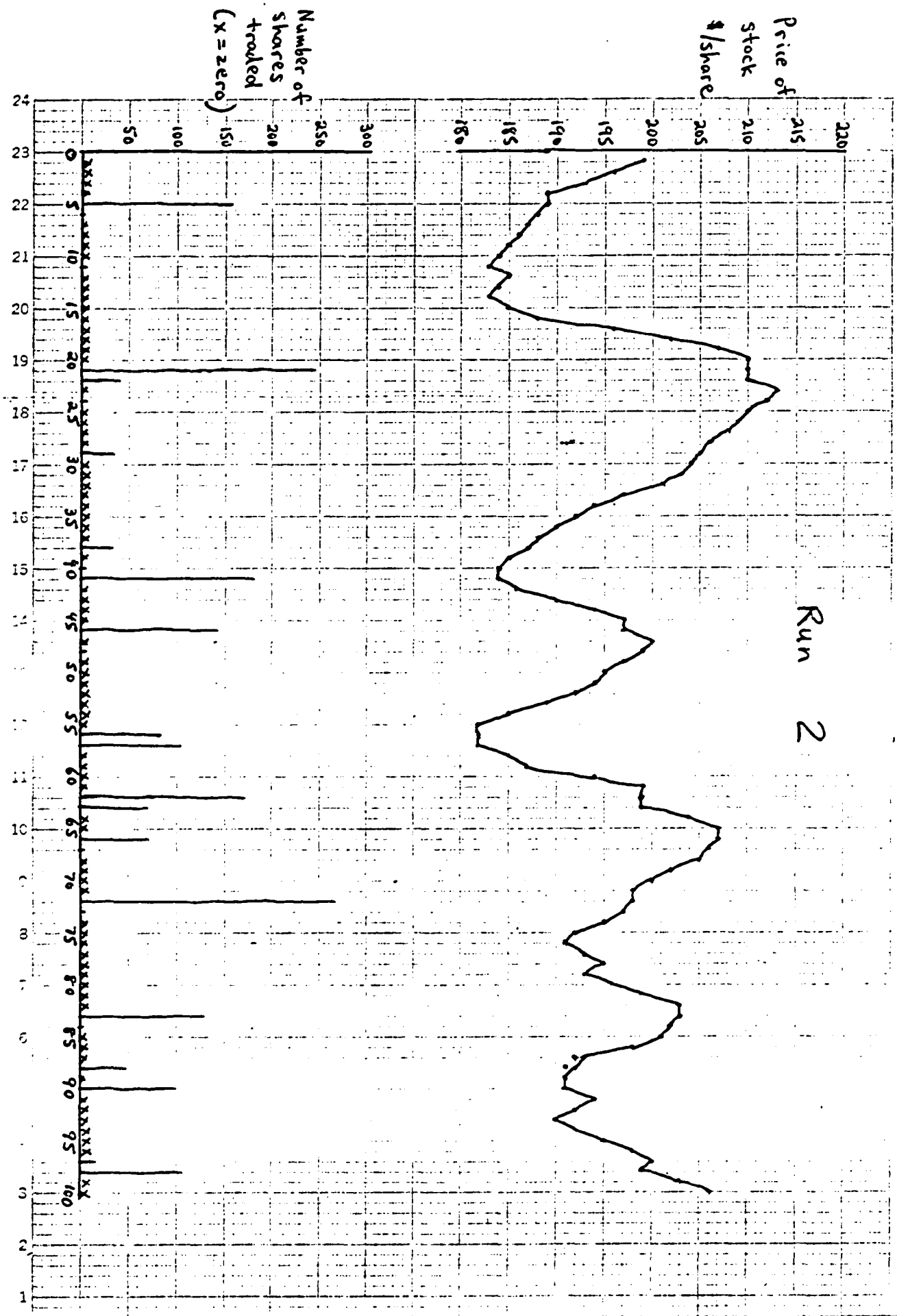
volume of trading.

Highlights of Run 2

	Initial Net Worth	Final Net Worth	Percentage Change
Fund. One	29850.	40628.5	36.1
Fund. Two	29850.	37348.2	25.1
Tech. One	29850.	28044.2	-6.1
Tech. Two	29850.	26176.2	-12.3
Tech.-Fund.	29850.	34816.0	16.6
Dest. Fund.	29850.	33402.6	11.9
Total	179100.	200415.7	11.9

In Run 2 the retention rate became .2 and this produced some changes in the outcome of the simulation. In general, the stock became a somewhat less desirable asset. Although the firm was increasing its assets and hence its potential earning power (the increase in assets was about 4% over the span of the simulation), this did not compensate the investors for the reduced dividend payments they were getting. Compared to Run 1 the price of the stock was usually about 5 or 6 points lower during the course of Run 2. The Gordon-Lerner-Carleton analysis of Chapter 3 would have resulted in a rise in the price of the stock with higher retention rate if the rate of return on the firm's assets exceeds the discount rate. However, this assumes the discount rate is independent of the retention rate and does not account for risk.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Also, it is a long-run analysis that assumes perfect foresight on the part of the investors. In the simulations we are concerned with short-run pricing and the investors are constantly revising their expectations.

Autocorrelation in the price series for Run 2 was appreciable. The regression equation for the price differences was $d_t = .076 + .634d_{t-1}$.

Highlights of Run 3

In Run 3 the retention rate was increased to .6 . The security became less desirable. Run 3 was stopped after 41 trading periods. During that time the price decreased monotonically from 199 to 118. As the price started to go down, the technicians tried to unload their holdings onto the two fundamentalists and the techno-fundamentalist. However, the latter three investors did not have enough cash to absorb all the offerings of the technicians. Hence, there were persistent limit orders to sell on the part of Technician Two.

The simulation was stopped because the rate of return for an investor went beyond the permissible range. The Tobin utility of return function is valid for $R \leq 1/2b$, where b is the coefficient of risk preference. When the price of the stock declined rapidly, this limit was exceeded and the simulation was halted.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

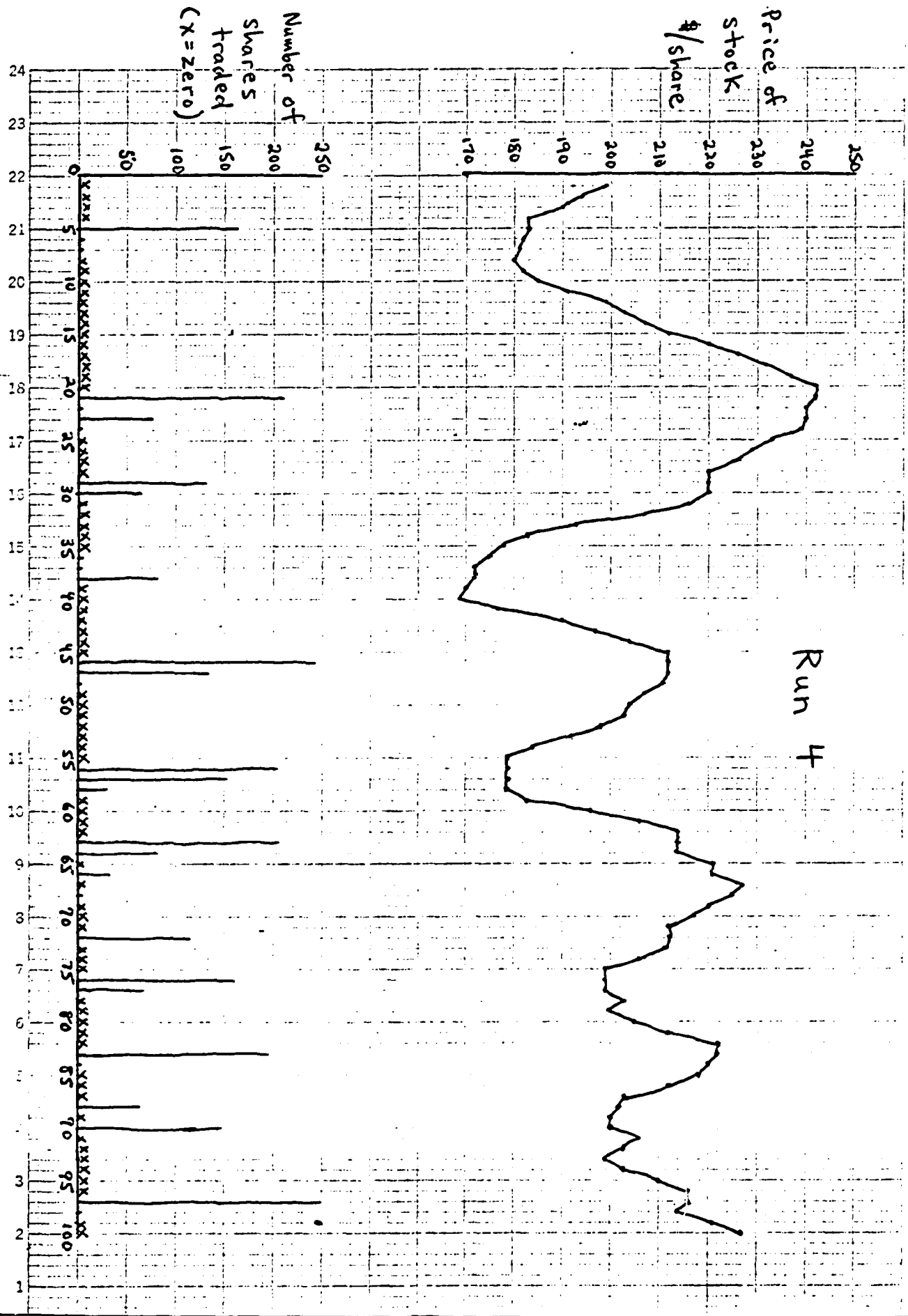
Highlights of Run 4

	Initial Net Worth	Final Net Worth	Percentage Change
Fund. One	29850.	43916.9	47.1
Fund. Two	29850.	52217.7	74.9
Tech. One	29850.	18029.9	-39.6
Tech. Two	29850.	24222.7	-18.9
Tech.-Fund.	29850.	41705.9	39.7
Dest. Fund.	29850.	36018.6	20.7
Total	179100.	216111.7	20.7

In Run 4 the variance of the disturbances is four times greater than in Run 1. It was believed this would produce more risk in the model and create greater variability in prices. A look at the figure for Run 4 shows that the price range of the stock was increased as compared with Run 1. The relative performance of the investors was accentuated. Both technicians suffered large losses with Technician One again doing worse than Technician Two. The two fundamentalists both did better than in Run 1.

Fundamentalist Two did better than Fundamentalist One. This suggests that, where there is great variability in the rate of return on the firm's assets, the slower adjusting fundamentalist will do better than his faster reacting colleague.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Highlights of Run 5

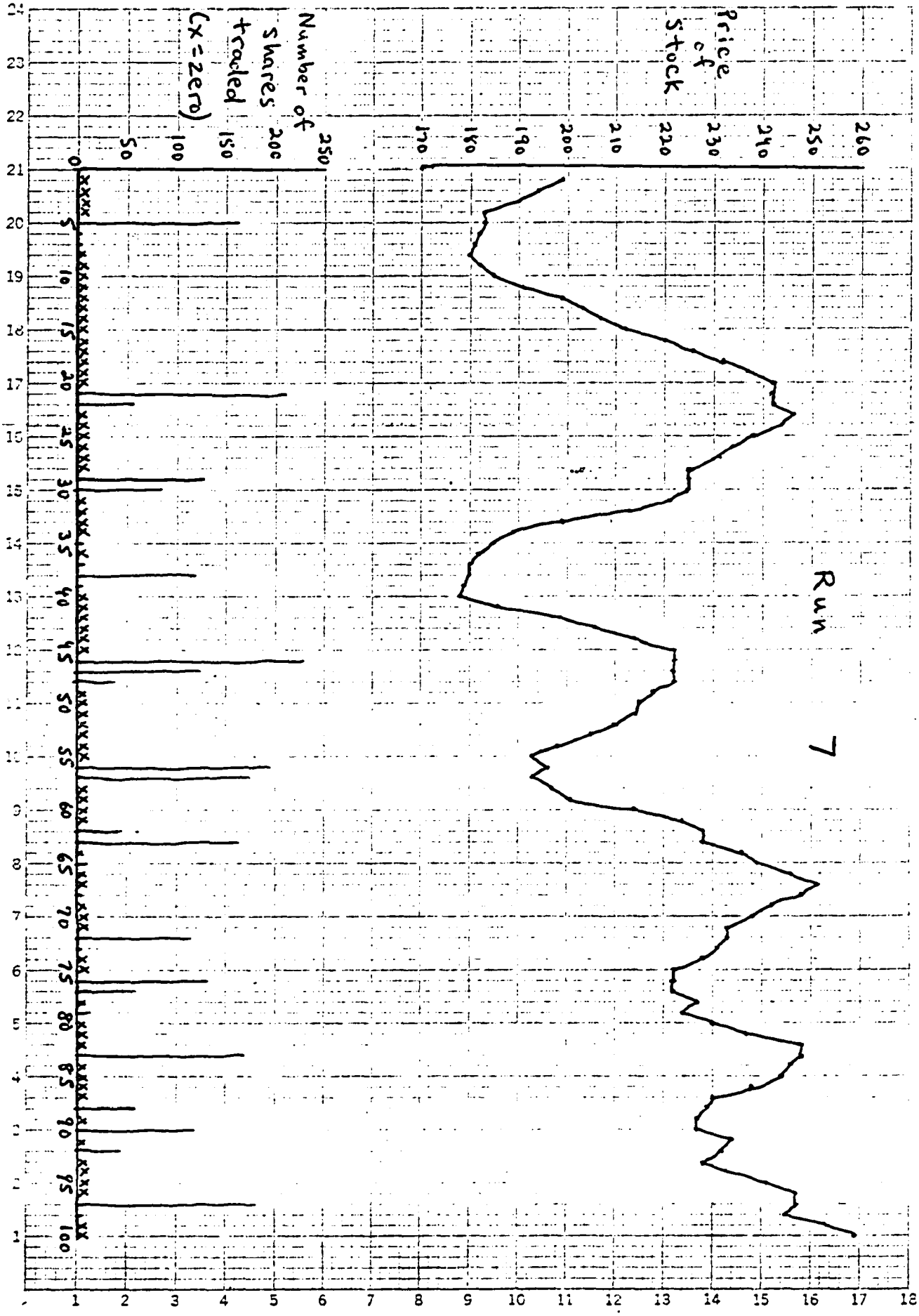
In Run 5 the firm had a positive retention rate. The variance of the disturbances was 1/225, or four times greater than in Run 2. Unlike Run 2, Run 5 was stopped after eleven periods. The situation was analogous to the Run 3 situation. The price started to fall and the technicians sold part of their holdings to the fundamentalists. However, Technician Two still wanted to dispose of shares, which the fundamentalists lacked the cash to purchase. The price was depressed still further. The price fell until the expected return from holding the stock fell outside the permissible range of the utility function, i.e. the return was greater than 1/2b, where b is the coefficient of risk preference. At this point the simulation was stopped.

Of course, one might have allowed the simulation to continue by making a modification in the program. The possibility existed that the price might subsequently rise so that the expected return would fall within the permissible limits. However, this was not done at this time.

Highlights of Run 6

As anticipated, Run 6 suffered the same fate as Run 5. It was stopped after eleven trading periods for the same reason.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Highlights of Run 7

	Initial Net Worth	Final Net Worth	Percentage Change
Fund. One	29850.	51017.6	70.9
Fund. Two	29850.	53836.4	80.4
Tech. One	29850.	19922.4	-33.3
Tech. Two	29850.	27328.0	-8.5
Tech.-Fund.	29850.	45032.9	50.9
Dest. Fund.	29850.	39427.5	32.1
Total	179100.	236664.8	32.1

In Run 7 a steady increase in the rate of return on the firm's assets was introduced. Over the course of the simulation, the price of the stock rose from 199 to 259, corresponding to the 20% change in the firm's rate of return from .10 to .12 . Although the path to the higher price levels was marked by many ups and downs (cf. diagram for Run 7), the higher return on the firm's assets eventually asserted its influence on the price of the stock.

The two technicians achieved miserable results again, with the slow-adapting technician doing worse than his colleague.

The regression equation for the price differences was $d_t = .299 + .662d_{t-1}$.

Highlights of Run 8

Run 8 was stopped after eleven trading periods for the familiar reason that an investor's expected rate of return was outside the permissible range of the utility function.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The results of Runs 1 to 8 furnish the following valuable conclusions:

1. Changes in the firm's retention rate will not radically affect the period-to-period changes in the simulation. Over the two-year period they will only have a slight effect since the firm's total assets will not be substantially changed.

2. The course of the firm's rate of return on assets may be more important, since a change in the rate of return from .10 to .12 implies a 20% change in the firm's earning power.

3. Of the investors in the model, the best results were achieved by the Fundamentalists, Techno-Fundamentalist, Destabilizing Fundamentalist, and Technicians, in that order. The fast-adapting technician usually did better than his slower counterpart. In future simulations an even faster adapting technician will be introduced and the consequent effects investigated.

4. The decision functions of the Destabilizing Fundamentalist precluded him from participating in any trading transactions.

5. In about 70% of the trading periods no inter-person trading took place, meaning that all the investors were on the same side of the market or did not place bid and asked orders. The introduction of a specialist could be used to produce continuity in trading, i.e. making

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

sure that some trading takes place every period. However, one must distinguish between continuity in trading and stabilization of the price series. A stock can go down in twelve successive periods on light volume or, as often occurred in the model, on no volume. Yet the situation will be substantially different only if the specialist had a sufficient "buffer" stock of cash to absorb the holdings offered for sale. If a specialist is introduced, the restriction that orders be of the "limit" variety can be removed and "market" orders allowed. In later simulations a specialist will be introduced, drawing on the valuable experience gained from these early runs.

6. In many cases the simulation was stopped because variables assumed values outside the permissible ranges of the utility function. In certain circumstances it might be feasible to continue the simulation, since not all investors will be in the same predicament at the same time.

7. Run 4 indicated that changes in the amount of exogenous risk could have important effects. Unfortunately, Runs 5 and 6 were not completed.

8. The high correlation in the price differences suggests the investors' adjustment parameter, γ, is too low. It often takes several periods to achieve the price change necessary to stimulate trading.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Simulation Runs 9 to 13

Tables 5-3 and 5-4 describe the structural characteristics of Runs 9 to 13. Three modifications in the program were made : the Destabilizing Fundamentalist gets his signals by comparing P_{t-1} with P_{t-3}; the second series of buy or sell limit orders is put in at the previous price plus 35% of the expected return to allow for the possibility of greater price adjustment; the program continues even if the variables take on values outside the normal ranges of the utility function (a program can be disregarded if this produces absurd results).

Two additional investors have been added. Technician Three shows a faster rate of adaptation than his two colleagues. The Speculator is a new investor "type" whose distinguishing feature is that he takes account of the second difference in the price series. If $\Delta P_t = P_t - P_{t-1}$, the Speculator believes that $\Delta P_t = \Delta P_{t-1} + \lambda \Delta^2 P_{t-1}$. The expected price, P_t^e, becomes

$$P_t^e = P_{t-1} + (P_{t-1} - P_{t-2}) + \lambda \left[(P_{t-1} - P_{t-2}) - (P_{t-2} - P_{t-3})\right] .$$

And if λ equals one,

$$P_t^e = 3P_{t-1} - 3P_{t-2} + P_{t-3} .$$

The Speculator shall use the above method to get the expected price. He shall adapt to the rate of return on assets with a Koyck weight of 0.1 and use it to derive the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 5-3: Common Structural Elements of Simulation Runs 9 to 13

Model Parameters

Market clearing system : Pooled clearing

Coefficient of risk preference = 1.5

Number of investors = 8

Adjustment coefficient for investors, $\gamma = .35$

Retention rate = 0.

Initial Conditions

Price of share = 199.

Assets/share = 100.

Each investor holds 100 shares of stock and $9950 in savings deposit for an initial net worth of $29850.

Investor Types

1. Fundamentalist One : Koyck weight of 0.1
2. Fundamentalist Two : Koyck weight of 0.05
3. Technician One : Koyck weight of 0.1
4. Technician Two : Koyck weight of 0.4
5. Techno-Fundamentalist : combination of Fundamentalist Two and Technician Two.
6. Destabilizing Fundamentalist : characteristics of Fundamentalist Two. Signals obtained by comparing P_{t-1} with P_{t-3}.
7. Speculator : Lambda equals one. Koyck weight of 0.1
8. Technician Three : Koyck weight of 0.7

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 5-4: Different Structural Elements of Simulation Runs 9 to 13

Run 9 : $r(t) = .10 + u(t)$, where $u(t)$ has mean zero and variance 1/900.

Run 10 : Same as Run 9, except that variance of Gaussian deviates equals 1/225.

Run 11 : Same as Run 9, except for changes in three investors below:

Technician One now has Koyck weight of 0.3

Technician Two now has Koyck weight of 0.5

Techno-Fundamentalist is a combination of Fundamentalist Two and Technician Two.

Run 12 : Same as Run 11, except that variance of Gaussian deviates is 1/225.

Run 13 : Same as Run 11, except that

$r(t) = .11 + u(t)$ in periods 21 to 30 and 61 to 70,

$r(t) = .12 + u(t)$ in periods 41 to 50.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

expected dividend yield. For the expected variance of return, he shall use the discrepancy between expected and actual rates, adapting with a Koyck weight of 0.1 .

Highlights of Runs 9 to 13

	Mean Price of Stock	Variance of Stock Prices
Run 9	201.50	161.4
Run 10	205.69	526.1
Run 11	202.01	159.7
Run 12	201.36	503.9
Run 13	211.68	167.2

In Runs 10 and 12 the variance of the Gaussian disturbances was four times greater than in Runs 9 and 11. This increased the variance in stock prices by a factor of about 3.2 .

The Speculator turned in the worst performance of the investors in all five runs. The way in which he formed his price expectation obviously caused his losses. In future simulation runs we shall not use such an investor "type". The other investors kept their performance ranking, with the fundamentalists, techno-fundamentalist, destabilizing fundamentalist, and technicians showing profits in descending order. Among the three technicians the slower adapting one did worse than his colleagues, but there was no persistent difference among the two other technicians.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The price differences in all the simulation runs exhibited a high degree of autocorrelation. Trading among investors took place in about 50% of the periods versus the 33% figure in Runs 1 to 8.

As compared with Run 11, the disturbances for Run 13 were modified for three stretches of ten periods each. From periods one to twenty the same stock prices were obtained in both runs. During periods 21 to 30 the stock price fell from 231 to 211 in Run 11, whereas in Run 13 it fell from 231 to 218. In Run 11 the stock price continued to fall to 178 over the next ten periods whereas in Run 13 it had fallen only to 186 even though the firm's earnings had been the same for ten periods. In periods 41 to 50 the price went from 178 to a high of 207 in periods 45 and 46 for Run 11; in Run 13 it went from 186 to a high of 228 in periods 48 and 49. By period 60 the price in Run 11 had fallen to 198; in Run 13 it had fallen to 204. Then, in Run 11 the price peaked at 212 in periods 64, 65, 66, and 67; but in Run 13 it peaked at 237 in periods 66 and 67. Even after the firm had experienced the same earnings pattern for twenty-five periods, i.e. by period 95, the price pattern of the stock differed. In Run 13 it was from four to seven points higher in the last five periods. Thus, the Koyck adaptive functions largely disregard the past fairly rapidly; but there is still a persistent effect of the past on present expectations.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Simulation Runs 14 to 19

In simulation runs 14 to 19 the buffered clearing system with a specialist was used to clear market orders from the investors. The characteristics of the simulation runs are noted in Tables 5-5 and 5-6. The simulations were designed to examine the sensitivity of the system to various aspects of the specialist's behavior and to focus on the interplay between the variance of the disturbances, the maximum permissible price change, and the specialist's initial holdings. (The reader may do well to refer to Chapter 4, for a reminder of how the buffered clearing system with a specialist works.)

Highlights of Run 14

	Final Net Worth	Percentage Change	Forecasting Variance
Fund. One	15941.6	-46.6	.00343
Fund. Two	27378.3	-8.3	.00575
Tech. One	26621.4	-10.8	.00933
Tech. Two	29432.0	-1.4	.01191
Tech.-Fund.	24804.2	-16.9	.00594
Dest. Fund.	27011.1	-9.5	.00575
Specialist	83166.1	109.0	
Total	234354.7	7.1	

Mean price of stock = 183.5 Variance of prices = 301.4

Total trading volume equalled 16217 shares of which specialist traded 42.9%.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 5-5: Common Structural Elements of Simulation Runs 14 to 19

Model Parameters

Market clearing system : Buffered clearing with specialist

Coefficient of risk preference = 1.5

Number of investors = 6

Retention rate = 0.

Initial Conditions

Price of share = 199.

Assets/share = 100.

Each investor holds 100 shares of stock and $9950 in savings deposit for an initial net worth of $29850.

Investor Types

1. Fundamentalist One : Koyck weight of 0.1
2. Fundamentalist Two : Koyck weight of 0.05
3. Technician One : Koyck weight of 0.1
4. Technician Two : Koyck weight of 0.4
5. Techno-Fundamentalist : combination of Fundamentalist Two and Technician Two.
6. Destabilizing Fundamentalist : characteristics of Fundamentalist Two. Signals obtained by comparing P_{t-1} with P_{t-4}.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 5-6: Different Structural Elements of Simulation Runs 14 to 19

Run 14 : $r(t) = .10 + u(t)$, where $u(t)$ has mean zero and variance 1/900.
Maximum permissible period-to-period price change, $\chi = .10$
Specialist starts with 100 shares of stock and $19900 for an initial net worth of $39800.

Run 15 : Same as Run 14, except that variance of Gaussian deviates is 1/225.

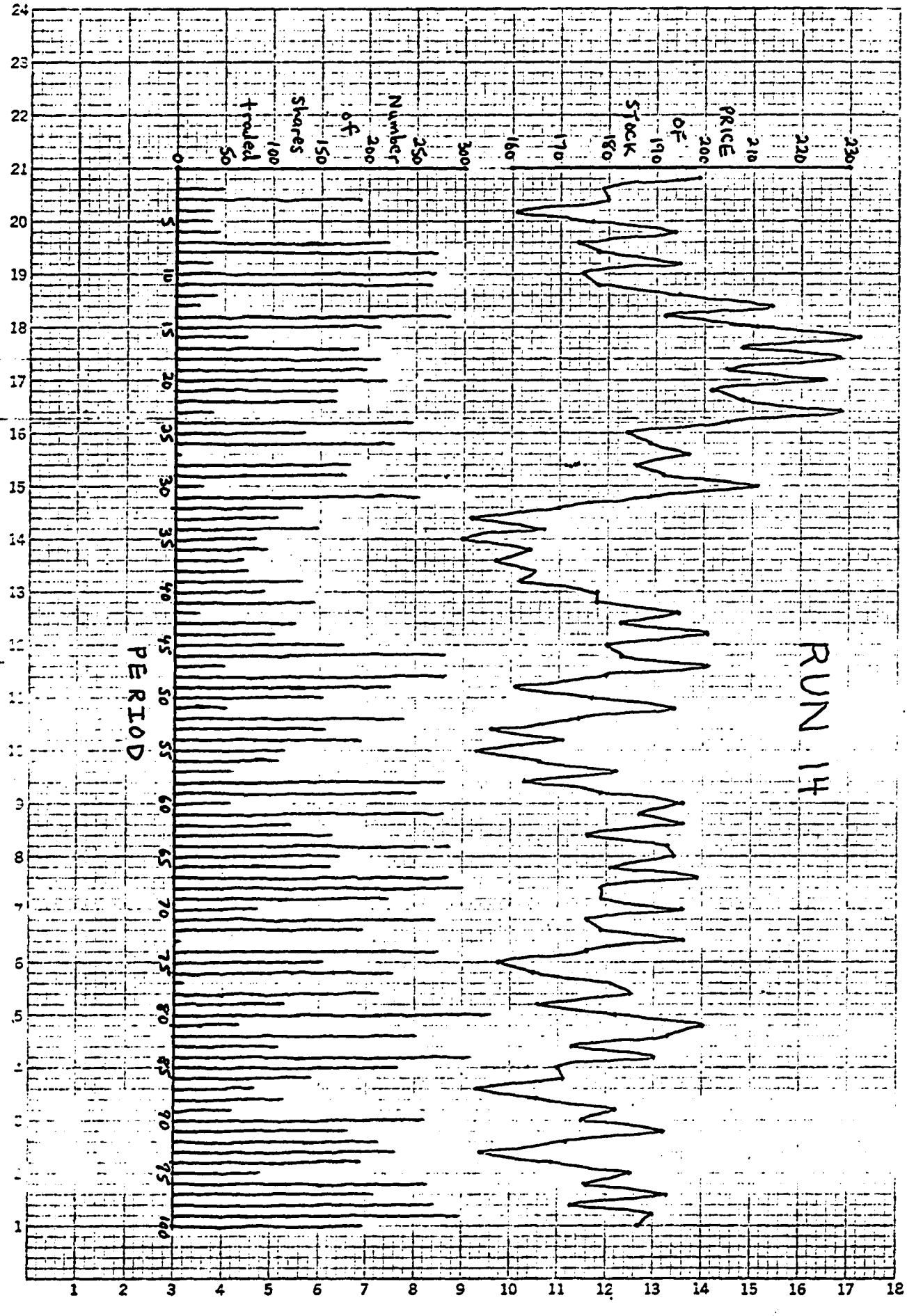
Run 16 : Same as Run 14, except that $\chi = .05$

Run 17 : Same as Run 14, except that $\chi = .05$ and variance of Gaussian deviates is 1/225.

Run 18 : Same as Run 14, except that $\chi = .05$ and specialist starts with 50 shares of stock and $9950 for an initial net worth of $19900.

Run 19 : $\chi = .05$
variance of Gaussian deviates is 1/225.
Specialist starts with 50 shares of stock and $9950 for an initial net worth of $19900.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

In Run 14 the specialist was able to generate huge profits for himself. Over the course of Run 14 the specialist increased his net worth by 109%; at the same time the six investors experienced losses ranging from -1.4% to -46.6%. What typically happened is that there was an imbalance of sell orders in the market. The specialist steps in and eliminates the imbalance in the quantity of orders; but he purchases shares at a discount from the previous market price, often as much as 10% below. If, in the next period, the specialist had to sell some shares from his account, he would sell them at a higher price, up to 10% above the price of the previous period. As contrasted to previous runs where the fundamentalists performed the stabilizing function, in Run 14 the specialist preempted their profits.

In an attempt to determine whether investor performance is related to forecasting ability, the "forecasting variance" was computed. This is the mean squared deviation of the actual rate of return from an investor's expected rate of return. It was found that a low "forecasting variance" did not imply superior investment performance in Run 14. This anomaly is probably due to the peculiar character of the market structure. For it is not enough to be able to forecast accurately the rate of return. One must also be able to effect changes in one's portfolio at a reasonable price to capitalize on

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

one's expectations. In Run 14 there were other investors with different forecasts and a specialist who exacted profits out of many transactions. If one avoided the market altogether (hypothetically from wrong forecasting) and held onto his initial holdings, he would have done better.

The regression equation for the price differences was $d_t = .0477 - .369d_{t-1}$. The negative sign reflects the "whipsaw" nature of the price series.

Highlights of Run 15

	Final Net Worth	Percentage Change	Forecasting Variance
Fund. One	17880.3	-40.1	.00730
Fund. Two	43589.8	46.0	.01001
Tech. One	20058.9	-32.8	.01265
Tech. Two	17493.0	-41.4	.01477
Tech.-Fund.	27577.8	-7.6	.00799
Dest. Fund.	36097.0	20.9	.01001
Specialist	68229.4	71.4	
Total	230926.2	5.5	

Mean price of stock = 181.9 Variance of stock prices = 612.9

Total trading volume was 12323 shares, of which the specialist traded 51.4%.

Run 15 is the same as Run 14 except that the variance of the Gaussian disturbances is four times greater.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Yet this was enough to affect the performance of the investors. Fundamentalist Two and the Destabilizing Fundamentalist achieved respectable profits. Technicians One and Two did much worse than in Run 14. The specialist's hefty profits were reduced from 109% to 71.4%.

Again the forecasting variance provides no explanation for relative investor performance.

The regression equation for the price differences was $d_t = .0228 - .0771 d_{t-1}$, so the "whipsaw" pattern was considerably reduced.

Compared to Run 14 the variance in prices is twice as great, total trading volume is about 25% less, but the specialist participated in 51.4% of the transactions versus 42.9%.

Highlights of Runs 16 and 17

	Run 16	Run 17
Mean price of stock	191.8	194.3
Variance of stock prices	197.8	532.4
Total trading volume	12535	7989
Specialist traded	42.2%	44.2%

In Runs 14 and 15 it appeared that the specialist overadjusted prices when there was an imbalance in the market and he stepped in to trade for his own account. In Runs 16 and 17 the maximum permissible price change, χ, was reduced to 5%.

In Runs 14 and 16 the Gaussian disturbances were

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the same. But the lower χ reduced the variance in prices by about 15%; it reduced trading volume by about a third; and the specialist's profits went from 71.4% to -14%.

Run 17 produced the remarkable result that the specialist turned in the worst performance of all the participants in the market. A detailed examination of the specialist's trading pattern reveals the source of this result. Briefly, the specialist tried to stabilize the market at unrealistic levels. For example, as the price of the stock receded from its high around 260 in period 20, the specialist found himself buying shares of the stock. Over the next ten periods he accumulated shares as the price ranged from 247 to 208. However, in period 31 there was an excess of sell orders in the market. At this time the specialist's cash holdings were small; and it took only very light volume to drive the price down from 208 to the 160 level by period 35. Then, the specialist tried to stabilize the price at the 160 level. As the price rose toward 170 he sold shares from his account. Thus, most of the shares which he purchased at prices from 247 to 208, he resold at prices from 160 to 180. This cycle of events was repeated in a similar fashion in periods 47 to 60.

In both Runs 16 and 17 χ was equal to .05 . But in Run 17 the variance of the disturbances was four times

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

greater and the specialist's profit went from 31% to -14%. In Run 15 where the variance of the disturbances was also 1/225 the specialist made 71.4%. It appears that the 5% constraint on prices imposed in Run 17 was inappropriate. Given the underlying disturbances, a greater period-to-period price adjustment was called for -- at least from the specialist's point of view. The great sensitivity shown by the model to changes in the parameters suggests that it may be a difficult task to design a control mechanism to stabilize market prices.

Highlights of Runs 18 and 19

The purpose of Run 18 was to determine whether the specialist could perform his function with fewer financial resources -- to be exact, starting with 50 shares of stock and $9950. It turned out that his resources were insufficient. After peaking at a price of 234 in period 16, the price started to decline. By period 26 it had reached 157 and the specialist had almost exhausted his cash reserves. At this point the expected rate of return for two of the six investors was outside the permissible range of the utility function. By period 34 and a price of 101 four of the investors' rate of return was outside permissible limits (the two exceptions being the technicians). The simulation was continued to the end;

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

but produced absurd results.

The specialist also started Run 19 with fewer financial resources. The reader will recall that in Run 17 the specialist lost money as he tried to stabilize the market at unrealistic levels. In Run 19 the same thing happened and the specialist suffered a loss of 53.8%. Total trading volume was about 35% less in Run 19 than in Run 17; but the variance of stock prices was about three times greater.

Simulation Runs 20 to 25

So far we have been using one set of Gaussian deviates, u(t). The numbers were drawn from a table of normally distributed deviates but only one set of 100 numbers was drawn. This has been used in every simulation up to now and can be referred to as set A. (In some runs the numbers were multiplied by a factor in order to change the variance of the set). To determine whether the results obtained from set A are typical, several of the simulations will be repeated with different sets of deviates, Sets B and C. We shall thus be able to see how sensitive the results are to a particular set of 100 numbers.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 5-7: Common Structural Elements of Simulation Runs 20 and 21

Model Parameters

Market clearing system : Pooled clearing

Retention rate = 0.

Coefficient of risk preference = 1.5

Number of investors = 6

Adjustment coefficient for investors, $\gamma = .35$

$r(t) = .10 + u(t)$

Initial conditions

Price of share = 199.

Assets/share = 100.

Each investor holds 100 shares of stock and $9950 in savings deposit for a total net worth of $29850.

Investor Types

1. Fundamentalist One : Koyck weight of 0.1
2. Fundamentalist Two : Koyck weight of 0.05
3. Technician One : Koyck weight of 0.1
4. Technician Two : Koyck weight of 0.4
5. Techno-Fundamentalist : combination of Fundamentalist Two and Technician Two.
6. Destabilizing Fundamentalist : characteristics of Fundamentalist Two. Signals obtained by comparing P_{t-1} with P_{t-4}.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Highlights of Runs 20 and 21

	Run 20 Set B	Run 21 Set C
% change in wealth of Fund. One	53.0	15.6
% change in wealth of Fund. Two	16.6	16.5
% change in wealth of Tech. One	-16.2	-17.6
% change in wealth of Tech. Two	-24.2	-1.5
% change in wealth of Tech.-Fund.	21.6	18.8
% change in wealth of Dest. Fund.	10.2	12.0
% change in total wealth	10.2	7.3
Mean price of stock	202.2	192.5
Variance of stock prices	282.7	162.9
Total trading volume	3172	2906

Except for the disturbance sets Runs 20 and 21 had the same structure (cf. Table 5-7). Four of the six investors did about the same in both runs; but Fundamentalist One and Technician Two achieved different results. The variance in stock prices was different; although the total trading volume was about the same.

Comparisons of Runs 14, 22, and 23

Runs 14, 22, and 23 had the same structural elements (cf. Tables 5-5 and 5-6); but different disturbance sets were used.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

	Run 14 Set A	Run 22 Set B	Run 23 Set C
% change for Fund. One	-46.6	-31.7	-52.8
% change for Fund. Two	-8.3	-9.6	-11.1
% change for Tech. One	-10.8	-6.5	-15.3
% change for Tech. Two	-1.4	-12.9	-8.1
% change for Tech.-Fund.	-16.9	-15.6	-27.4
% change for Dest. Fund.	-9.5	-5.1	-9.4
% change for Specialist	109.0	76.6	90.1
% change in total wealth	7.1	2.8	-0.6
Mean price of stock	183.5	180.4	173.3
Variance of stock prices	301.4	337.6	224.8
Total trading volume	16217	13020	14620
Specialist traded	42.9%	48.0%	46.8%

The comparison of these three runs shows that they bear a strong resemblance to each other and are definitely cast from a common mold. The absolute figures for the investors' performance vary, but qualitatively, the results are similar.

The regression equations for the price differences are:

Run 14 : $d_t = .0477 - .369d_{t-1}$

Run 22 : $d_t = -.193 - .348d_{t-1}$

Run 23 : $d_t = -.668 - .389d_{t-1}$

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Comparison of Runs 16, 24, and 25

Runs 16, 24, and 25 had the same structural elements (cf. Tables 5-5 and 5-6); but different disturbance sets were used.

	Run 16 Set A	Run 24 Set B	Run 25 Set C
% change for Fund. One	4.8	-14.7	-19.5
% change for Fund. Two	31.6	23.7	22.9
% change for Tech. One	-17.5	-8.0	-16.9
% change for Tech. Two	-15.7	6.7	-0.5
% change for Tech.-Fund.	10.4	1.0	5.3
% change for Dest. Fund.	10.9	12.7	2.6
% change for Specialist	31.0	36.3	20.9
% change in total wealth	9.0	9.5	3.0
Mean price of stock	191.8	198.3	179.4
Variance of stock prices	197.8	290.6	173.0
Total trading volume	12535	11515	13157
Specialist traded	42.2%	47.3%	41.7%

Mixed comparisons are possible for these three runs. Fundamentalist Two was the best performer in all three. Total trading volume and the specialist's participation in the trading exhibited close patterns. However, in general, there were as many dissimilarities as similarities.

* * * * *

We have seen that the simulation runs are sensitive

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

to the particular set of Gaussian deviates used. While this is a valuable result in itself, suggesting that the same investor behavior will lead to different outcomes depending on the circumstances; it makes generalizations about particular structures very difficult to establish.

Simulation Runs 26 to 29

In the next four runs we shall examine whether a technical investor can improve his performance by revising the Koyck weight in his adaptation function. It may be argued that an investor's Koyck weight should not be constant throughout the entire simulation; but that he should learn as time goes on. In Run 26 Technician Three shall revise his Koyck weight as the process is going on. The other two Technicians shall maintain constant weights. They will serve as "controls" in the comparison with Technician Three.

Every ten periods the third Technician shall calculate the Koyck weight (to the nearest tenth) which would have given the smallest forecasting variance for the past ten periods. This "ex post Koyck weight" shall become his adaptation weight in the next ten periods. The percentage changes in the net worth of the three Technicians shall be calculated every ten periods.

The common structural elements of the four simulation runs are presented in Table 5-8.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 5-8 : Common Structural Elements of Simulation Runs 26 to 29

Model Parameters

Market clearing system: Buffered clearing with specialist

Maximum permissible price change, $\chi = .05$

Coefficient of risk preference = 1.5

Number of investors = 7 Retention rate = 0.

$r(t) = .10 + u(t)$, where $u(t)$ has mean zero and variance 1/900.

Initial Conditions

Price of share = 199.

Assets/share = 100.

Each investor holds 100 shares of stock and $9950 in savings deposit for total net worth of $29850.

Specialist starts with 130 shares of stock and $25870 for initial net worth of $51740.

Investor Types

1. Fundamentalist One : Koyck weight of 0.1
2. Fundamentalist Two : Koyck weight of 0.05
3. Technician One : Koyck weight of 0.1
4. Technician Two : Koyck weight of 0.4
5. Techno-Fundamentalist : combination of Fundamentalist Two and Technician Two.
6. Destabilizing Fundamentalist : characteristics of Fundamentalist Two. Signals obtained by comparing P_{t-1} with P_{t-4}.
7. Technician Three : Koyck weight of 0.3 for first ten periods; then Koyck weight is revised every ten periods.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Highlights of Run 26: Disturbance Set A Used

Period	Technician One Koyck wt. 0.1 Perc. change	Technician Two Koyck wt. 0.4 Perc. change	Technician Three Ex Post Koyck wt. used	Perc. change
1-10	-7.01	-5.40	.3	-5.00
11-20	12.29	8.40	.7	0.20
21-30	-10.63	5.86	.1	-8.44
31-40	-4.24	-16.41	.1	-4.05
41-50	-2.91	3.54	.1	-2.89
51-60	-2.27	0.09	.1	-2.26
61-70	-3.75	-2.72	.3	-4.19
71-80	1.04	-1.42	.1	1.73
81-90	-4.92	-1.50	.1	-5.03
91-100	-6.02	-10.71	1.0	-9.18
1-100	-26.32	-20.68		-33.28

In periods 1-10 there was a high degree of auto-correlation in the price differences. Thus, a Koyck weight of 0.7 would have given the smallest forecasting variance. The actual weights of the technicians were .1, .4, and .3 . The technicians with the higher weights tended to do somewhat better in periods 1-10. For periods 11-20 Technician Three used the weight of 0.7 that would have given the smallest forecasting variance in the previous ten periods. But alas, periods 11-20 were unlike periods 1-10. A Koyck weight of 0.1 would have

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

given the smallest forecasting variance. Technician One, who had that weight, did very well in periods 11-20.

In general, in Run 26 no group of ten periods provided a good clue to the behavior of the process in the subsequent ten periods. Thus, it was of slight value to revise one's weight every ten periods. Since prices resembled a "random walk", this is not surprising. The equation for the price differences was $d_t = .234 + .00817 d_{t-1}$.

* * * * *

In Run 27 disturbance set B was used. In Run 28 disturbance set C was used. In Run 29 disturbance set A was used but χ was increased to .10 . The results of these runs confirmed Run 26, namely there was no evidence that a revision in the Koyck weight be Technician Three had any beneficial effect on his performance.

Summary of Simulation Runs 1 to 29

After twenty-nine simulation runs a recapitulation of the results obtained should be useful.

1. If there was some rational motivation behind investors' decision functions, the more rational investor generally performed better. For example, technicians relied on the past course of prices. Where there was positive autocorrelation in the price series, the faster adapting technician usually did better. The fundamentalists, on the other hand, adapted to disturbances in the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

rate of return. Since there was no pattern to the disturbances, i.e. they were random, it would have been better to ignore them. Thus, Fundamentalist Two, who had the smaller Koyck weight, did better in fifteen of the twenty-four completed simulation runs.

2. Changes in the firm's retention rate did not radically affect the period-to-period changes in the prices. Over the two-year period of the simulation they will have only a slight effect since the firm's total assets will not be substantially changed. A parallel exists in the real world where, very often, short-term factors exert a strong influence on stock prices. The Gordon-Lerner-Carleton approach is a long-term equilibrium proposition.

3. When the variance of the disturbances was quadrupled, the variance in the stock price increased by about three times in the case where there was no specialist. When there was a specialist, the variance increased by less than three times, sometimes as low as two times.

The stock price variance was also influenced by the particular set of Gaussian deviates used -- the variability between the highest and lowest being around 100%.

4. When the specialist is clearing the market, there is some optimal value for the percentage change in price

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

which he should be permitted to effect. In Runs 14 and 16, where the variance of the disturbances was the same, but 10% changes were allowed in Run 14 and 5% in Run 16, it seems that the 5% limit is better. In Run 14 there was negative autocorrelation in the price series, indicative of over-reaction on the part of the specialist; but, on the other hand, very profitable for him since he made 109% in Run 14. In Run 16 limiting price changes to 5% produced insignificant autocorrelation in the price series and profits of 31% for the specialist.

In Runs 15 and 17 prices were constrained to 10% and 5% changes, respectively; but the variance of the disturbances was four times greater than in Runs 14 and 16. Here Run 15 produced insignificant autocorrelation and profits of 71.4%; while Run 17 produced a loss of 14% for the specialist and a slight positive autocorrelation, suggesting that 5% changes were not sufficient.

5. When comparing pooled clearing to buffered clearing, the existence of the specialist produced a tremendous increase in the volume of trading. From a situation in which trading occurred in less than half the periods and totalled about 3000 shares in a single run, the introduction of a specialist led to trading in every period and a trading volume of around 12000 shares per run.

One may wonder whether much of the trading was ex-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

cessive and induced by the presence of the specialist in the market. On the plus side it is pretty clear that he afforded the investors the means to effect changes in their stockholdings more readily; but one must question whether this was a boon to the investors or to the specialist. In addition, although the model did not incorporate them, there are commissions and transfer costs to consider.

6. The model tended to be quite sensitive to changes in its parameters or structures. This was illustrated when different sets of Gaussian deviates were used for particular runs. Whether there is a parallel here with real world investors where a stock may vary in price by 10 or 15% in a week for no discernible reason, the reader can weigh for himself.

7. In several runs the expected rate of return for the investors fell outside the valid range. Since this will tend to produce absurd results, one would have to make modifications in the program to allow the simulation to continue.

8. In a non-competitive market where the specialist can affect the terms on which you can alter your portfolio, the ability to forecast correctly may be of slight value.

9. When comparing Fundamentalist Two with the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Destabilizing Fundamentalist, who changed his holdings much less frequently since he needed signals before doing so, some interesting patterns emerge. Fundamentalist Two did better in twenty of the twenty-four completed runs. There were nineteen runs in which Fundamentalist Two finished with a positive change in his net worth; and in all of these he did better than the Destabilizing Fundamentalist. In five runs Fundamentalist Two showed losses by the end of the simulation; and in four of these five he was outperformed by the Destabilizing Fundamentalist.

Rapid turnover of one's holdings seems to enable one to capitalize on market opportunities; whereas a policy of avoiding the market will lead to smaller losses in unfavorable circumstances.

10. If the specialist is not adequately capitalized, he will be unable to stabilize the market effectively and will incur large losses, as evidenced in Runs 18 and 19.

In most of the simulation runs the specialist's own trading as a percentage of the total was about 45%. In Run 19 where his capital was one-half of his capital in Runs 14-17, he accounted for about 23% of the trading; and as compared with Run 17 the variance of the stock prices in Run 19 was three times as great.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Supplementary Note: A Correlationist

In several of the preceding simulation runs the autocorrelation in successive price differences was significantly different from zero. For instance, where the buffered specialist clearing system with a 10% permissible limit on period-to-period price changes was used, the autocorrelation was negative. This "whipsaw" pattern produced large profits for the specialist. It also raises a possibility that an investor who takes account of the autocorrelation in the price differences can use this as a basis for investing. Such an investor may be called, for lack of a better term, a Correlationist.

The behavior pattern of a Correlationist must be prescribed if he is to be introduced into a simulation run. We shall have him behave according to very simple rules so that there can be little doubt about the pattern of his trading. Using the past series of prices, the Correlationist will calculate the correlation coefficient for successive price changes. Call this calculated coefficient at any time t, c_t. Let $\Delta P_{t-1} = P_{t-1} - P_{t-2}$ be the price difference between the actual prices at time t-1 and t-2. The Correlationist will calculate the expected price for period t, P_t^e as $P_t^e = P_{t-1} + c_{t-1}\Delta P_{t-1}$.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

We shall introduce a Correlationist into Runs 14 and 22. The Correlationist will not trade during the first thirty periods. He shall use that time to calculate the correlation coefficient for price changes for the first thirty periods. At the end of each succeeding period he shall recalculate the correlation coefficient, taking into account the additional observation. Since the coefficient will be negative for Runs 14 and 22, we shall have the Correlationist:

Sell up to ¼ of his stock holdings if $P_t^e > P_{t-1}$;

Buy shares with up to ¼ of his cash holdings if $P_t^e < P_{t-1}$.

In this way he will try to profit from the "whipsaw" pattern in the price series.

The figures below reproduce the results for Runs 14 and 22; these are compared with the new simulation runs where a Correlationist has been introduced.

	Run 14		Run 22	
	Before	After	Before	After
% change for Fund. One	-46.6	-43.1	-31.7	-55.0
% change for Fund. Two	-8.3	2.4	-9.6	-9.7
% change for Tech. One	-10.8	-8.5	-6.5	-22.2
% change for Tech. Two	-1.4	-15.8	-12.9	-4.0
% change for Tech.-Fund.	-16.9	1.5	-15.6	-18.7
% change for Dest. Fund.	-9.5	-1.8	-5.1	7.7
% change for Correlationist		1.0		-5.6
% change for Specialist	109.0	115.7	76.6	49.7

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

	Run 14		Run 22	
	Before	After	Before	After
% change in total wealth	7.1	10.8	2.8	-5.0
Variance of stock prices	301.4	343.5	337.6	625.7
Corr. coef. for prices	-.37	-.33	-.35	-.21

In both cases the correlation coefficient for the observed price differences was reduced. In Run 14 it went from -.37 to -.33; in Run 22 the reduction was from -.35 to -.21 . Thus the Correlationist achieved his avowed purpose of reducing the correlation in the price differences. He did not make large profits by doing this; profits were still largely preempted by the specialist. Nor did he substantially alter the investment performance of the other six investors.

We should notice that the reduction in the correlation coefficient produced a greater variance in stock prices. Given a "whipsaw" pattern in the price series, the variance will not be large. But as the correlation coefficient is lowered, the prices are able to wander more and a larger price variance results.

It can be argued that the deterministic behavior of the other six investors is not very plausible. These investors adapt to new information; but their behavior parameters remain fixed. It would be better, one can argue, if the investors learned from their mistakes and

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

altered their behavior patterns. Thus, if we specifically introduce a Correlationist, he can take account of the correlation in the price series and turn in a respectable performance in comparison with the other investors. But the Correlationist doesn't really "learn" either. If he did, he would alter his behavior as time passed. For example, if he perceived that he was successful in reducing the correlation, he would alter his buying and selling rules. If the correlation became very small, he would cease being a Correlationist. Would he then decide that it is wise to become a Fundamentalist? Or someone who searches for cycles in a price series? The intelligence factor that seems necessary for true "learning" to occur is a formidable concept to represent in a computer simulation. Claiming the pious excuse of human limitation, that problem will be left for future research.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 6 : The Stock Market and the Number of Investors

Markets are designed to bring buyers and sellers together. By doing this they facilitate transactions among individuals. We usually say that a perfectly competitive market requires large numbers of buyers and sellers. We also add the qualification that no single buyer or seller be so large in relation to the others that he can affect the price in the market through his actions. Since these ideal conditions rarely exist, we retreat to the less stringent concept of "workable competition." Whether a market can then be characterized as competitive will depend on the criteria which one chooses to set up.

In the real world the potential investors in a certain security run into the millions. If the security is brought to an investor's attention and the price is right, he might conceivably enter the market to buy and sell the security. However, if investors remain potential investors and never enter the marketplace, for practical purposes of determining a security's price, they can be disregarded. Asset prices are determined by the confluence of buy and sell orders. Which investors are likely to place these orders? First of all, the present shareholders of a company's stock would be extremely likely to pay attention to the price of their holdings. A closer examination would reveal that this is not the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

case. For many large corporations the turnover in their shares amounts to about 10% a year; i.e. total trading volume for the year is 10% of the shares outstanding. Despite the fact that the company's stock might fluctuate by as much as 50%, ninety percent of the stockholders are content to sit with their holdings. If these people are long-term investors, their inaction might be justifiable in their eyes. On the other hand, the stock price in the short-run is independent of the actions of the vast percentage of the stockholders. As the period of time under consideration gets smaller, fewer people influence the price of the stock; until, in the limit, the price is determined by the two parties to the last transaction.

Some Simple Models

Can a model be constructed which will explain how the number of investors and their size will affect the market for a stock? One possibility is to construct a model which will give us an analytic solution. Let us assume there are two individuals in the market, one of whom reacts to past price behavior.

1. $D_{1t} = -ap_t + b$
2. $D_{2t} = -cp_t + d + e(p_{t-1} - p_{t-2})$

where D_{it} is the quantity demanded by individual i at time t. We can determine a solution that net excess demand is zero at each point in time, or

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

$$D_{1t} + D_{2t} = 0.$$

By adding additional investors, say D_3 and D_4, we can determine a new analytic solution and see what effect more investors have on the price series. Such an approach, however, has serious drawbacks.

1. There are no budget constraints on the investors. They are assumed to have no difficulty in making the net purchases or sales prescribed by their demand functions. They are thus unlike real world investors whose financial resources are limited.

2. Once the demand equations are written down, the solution to the system is determined. Since the solution is determined forever in the first period, this cannot be a model where investors adapt to exogenous shocks or disturbances and change their demand functions.

3. Adding a new investor will change the nature of the model. It is difficult to disentangle the effects caused by the addition of investors from the effects occasioned by structural changes in the model. If the new investors have different demand functions than the old investors, it is clear we are doing something more than adding new investors. If their demand functions are identical to the old ones, we are merely changing the relative proportions of the investors. We could rewrite the clearing equations as

$$n_1 D_{1t} + n_2 D_{2t} = 0,$$

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

where n_1 and n_2 are the number of type 1 and type 2 investors, respectively.

4. There is no way to investigate the effect of more investors on market clearing, since the market is always clearing excess demand. Presumably, one advantage of a large number of investors is greater activity in a security and ease in making transactions. There is no scope for this when an equation takes care of market clearing.

To illustrate some salient features of a market with a small number of investors, let's consider some stylized examples.

Imagine a world with two investors, a riskless asset which gives them a certain fixed yield, and an equity asset with all earnings paid out as dividends. Assume the rate of return on the firm's capital is given by

$$r(t) = \text{constant} + u(t)$$

where u(t) is normally distributed with mean zero and variance σ^2. What will the equilibrium price for the risky asset be? We need to specify the investors' degree of risk aversion. Then there will be a relationship between the price of the stock and the proportion of their wealth that investors have in each asset. Assume that they perceive the parameters of the probability density function correctly. Then, if they are to hold a larger portion of their wealth in the risky asset, the expected return on

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the asset should be higher and the price, consequently, lower.

In summary, the investors will determine an equilibrium price, P_o; this will tell us what fraction of his wealth each investor has in the stock. P_o is an equilibrium price since the investors correctly perceive the expected rate of return. With no variation in the price of the stock the variance in the rate of return is determined by the earnings variability and the correct perception of σ^2 by the investors will enable them to calculate the expected variance in the rate of return. But P_o is such that they are induced to accept this amount of risk.

Example 1. Let us assume the investors have the same degree of risk aversion and identical initial holdings of the two assets. Let them start off with 100 shares of stock with P_o = \$100 and \$5000 of the riskless asset. Each investor thus has \$15,000; two-thirds in stock and one-third in the riskless asset.

Suppose Investor 2 now wants to liquidate his stock holdings. We may imagine that he has a pressing need for cash. Investor 2 will seek to sell his shares to Investor 1 and the manner in which he proceeds can sharply affect the price of the stock. Investor 2 might sell all his 100 shares to Investor 1 for \$50 each. Thus, there would be a sharp drop of 50% in the price of the stock for one period to accomplish the successful liquidation of Investor 2's holdings. Investor 1 will be glad to pick up the shares at \$50 each, since his views about the stock

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

haven't changed. In subsequent periods we can regard the price as having returned to near $100, reflecting the willingness of Investor 1 to buy or sell near this price.

Example 2. However, Investor 2 might succeed in selling some of his shares at a price higher than $50. In an extreme case, let us assume he sold 50 shares to Investor 1 at a price of $100. This will absorb all of Investor 1's holdings of the riskless asset. But Investor 2 would still be left with 50 shares to sell. With Investor 1 unable to purchase any more shares, a hypothetical price for the stock would be the price at which Investor 2 was willing to sell. Conceivably, the price could fall to almost zero if Investor 2 desperately wanted to sell his shares. This example illustrates the case of a "liquidity crisis" where the market is unable to absorb the quantity offered for sale.

* * * * *

What results emerge from a market with a small number of investors will be particularly sensitive to the way the model is structured. The adjustment functions of the investors will have to be defined. The market clearing mechanism should be flexible enough to deal with a wide constellation of orders. Since supply and demand will rarely be in balance, one must specify how orders are executed and the prices of transactions determined.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Changing the Number of Investors in the Simulation Model

We shall use the familiar simulation model to investigate whether changing the number of investors has an effect on market performance. We shall judge the results by two criteria: we shall look at the variance of the price series which is generated; and we shall look at the proportion of *ex ante* orders cleared by the market. (Since not all orders are cleared there will be a difference between the *ex post* volume of transactions and the *ex ante* volume of orders entered.)

The six investors used in previous work will be in the model: two Fundamentalists, two Technicians, a Techno-Fundamentalist, and a Destabilizing Fundamentalist. We shall then vary the number of additional investors in the market. We then have to postulate some type of behavior for these additional investors. In doing this, one wants to be able to add more investors without having to prescribe characteristic parameters for them and thereby altering the structure of the model. The Basic Behavior equation for the new investors will be

$$a^*(t) = a_o(1 + u(t)) \qquad 0 \leq a^*(t) \leq 1$$

where $a^*(t)$ is the desired fraction of total wealth to be invested in the stock at time t;

a_o is the initial proportion of wealth held in the form of stock;

$u(t)$ is a random number drawn from a table of normally distributed deviates.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

All the new investors will be described by the above equation; but they shall each be subject to a different set of normal random numbers. Thus, for the first new investor the disturbance set will be Set A, for the second Set B, and for the third Set C. The Basic Behavior equation is a construct to facilitate the analysis. It is not suggested that investors are subject to these random shifts from equities into cash and vice-versa. At any time in the marketplace, however, there are investors liquidating assets to meet extraordinary living expenses just as there are others buying stock because they happen to have the cash to do it. If one prefers, he can think of each new investor being the composite of several identical investors, each of whom gets in and out of the market completely at random points in time.

Besides varying the number of investors, one can endow them with different initial resources. This shall be called the "scale" parameter. A Scale 1 investor will start with an initial portfolio of stock and cash. A Scale 2 investor will start with twice as much stock and twice as much cash; etc.

Since there are exogenous disturbances in the Basic Behavior equation for the new investors, this will keep the simulation going. One can then dispense with the earnings shocks which have been used in previous work.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

By keeping the firm's earnings constant throughout the simulation, we can concentrate on the effects produced by the inclusion of more investors and/or varying the scale at which they operate.

The questions to be answered through the simulation model are:

1. Does increasing the number of investors at constant "scale" increase or reduce the variance of stock prices? At times the new investors will be on the same side of the market and at other times on opposite sides. Thus, they will occasionally reinforce each other and occasionally offset each other. The original six investors will be obliged to react to their market orders and the price series that will emerge may exhibit greater or lesser variance.

2. Keeping the number of new investors constant, does changing the scale at which they operate influence the course of prices? If the new investors become larger in size, the orders they place will tend to be larger.

3. What happens to the proportion of <u>ex ante</u> orders cleared when the number and scale of the new investors is changed?

The pooled clearing and buffered clearing systems were both used. As the new investors sought to bring desired and actual holdings into line, they would place orders for the right number of shares. Under the buffered clearing system the quantity to be bought or sold is

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

entered, since the specialist determines the market price. Under pooled clearing orders are of the "limit" variety. The adjustment coefficient, γ, was set at 3% of the previous period's price. Table 6-1 and Table 6-2 list the structural characteristics of the simulation runs.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 6-1. Common Structural Characteristics of Chapter 6 Simulation Runs.

Model Parameters

Coefficient of risk preference = 1.5

Retention rate = 0

r(t) = .10

Initial Conditions

Price of share = 199.

Assets/share = 100.

The original six investors below start with 100 shares of stock and $9950 in savings deposits for an initial net worth of $29850.

Original Six Investors

1. Fundamentalist One : Koyck weight of 0.1
2. Fundamentalist Two : Koyck weight of 0.05
3. Technician One : Koyck weight of 0.1
4. Technician Two : Koyck weight of 0.4
5. Techno-Fundamentalist : combination of Fundamentalist Two and Technician Two.
6. Destabilizing Fundamentalist : characteristics of Fundamentalist Two. Signals obtained by comparing P_{t-1} with P_{t-4}.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 6-2. Different Structural Elements of Chapter 6 Simulation Runs.

Number of Investors Added to Original Six

From one to three new investors will be added to a simulation run. The Basic Behavior equation for these investors is

$a^*(t) = .5(1 + u(t))$ where $u(t)$ has mean zero and variance 1/25.

For the 1st new investor, $u(t)$ will come from Set A disturbances.

For the 2nd new investor, $u(t)$ will come from Set B.

For the 3rd new investor, $u(t)$ will come from Set C.

Scale of Investors

The new investors will operate at varying "scale". A Scale 1 initial position will consist of 100 shares of stock and $19900 for an initial net worth of $39800. Scale 2 and Scale 4 will be proportional multiples of Scale 1.

Market Clearing System

When the pooled clearing system is used, γ shall be .35 for the original six investors and 3% of the previous price for the new investors.

When the buffered clearing system is used, χ shall be .10 and the specialist shall start with 130 shares of stock and $25870 for an initial net worth of $51740.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Discussion of Results

Looking at the results in Tables 6-3 and 6-4, we can answer some of our questions.

Increasing the number of investors, keeping the "scale" of operation constant, reduces the variance of the price series. For the buffered specialist system this was always the case. The price variance for a given "scale" decreases as we move from left to right along each row. For the pooled clearing system there is also a tendency for the variance to decrease as the number of investors is increased; but the effect is not as pronounced and clear-cut.

Regarding the price variance, there was no pattern to the "scale" effect. In some cases the variance increased with greater "scale" and in some cases it was reduced.

In the pooled clearing system, there was a slight tendency for the proportion of orders cleared to increase with greater scale. In the buffered specialist system, the reverse tendency was observed -- the proportion of orders cleared fell as the scale increased. The number of investors in a simulation run did not seem to have a definite effect on the proportion of orders cleared.

In seeking to analyze the results we are in a quandary analogous to oligopoly theory. We don't have a general theory to tell us what will happen when we increase the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 6-3. Price Variance and Proportion of Ex Ante Orders Cleared (in parentheses) with Pooled Clearing.

Scale of New Investors	1	2	3
Scale 4	27.25 (.565)	9.87 (.601)	18.67 (.595)
Scale 2	24.68 (.545)	9.33 (.634)	16.33 (.577)
Scale 1	49.21 (.461)	22.75 (.535)	15.96 (.536)

Number of New Investors Added to Original Six

Table 6-4. Price Variance and Proportion of Ex Ante Orders Cleared (in parentheses) with Buffered Specialist.

Scale of New Investors	1	2	3
Scale 4	194.63 (.873)	142.1 (.833)	118.1 (.831)
Scale 2	223.8 (.891)	132.7 (.859)	114.1 (.876)
Scale 1	169.1 (.893)	159.4 (.902)	123.8 (.892)

Number of New Investors Added to Original Six

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

number of firms in a market from six to seven or eight. The outcome depends on what assumptions we make concerning the firms' behavior, costs, marketing policies, strategies, etc.

An explanation of the results should analyze the ways in which the two market systems react to the disturbances. Consider the pooled clearing system with one new investor. The new investor must try to bring desired and actual holdings into line. He can go part of the way in doing this if the original six investors can be induced to alter their portfolios and place limit orders. To accomplish this the new investor will have to make it attractive for the old investors to change their holdings. In the simulation runs the new investors turned in a performance below that of the market's as they constantly sought to shift their portfolios. In the pooled clearing system the Fundamentalists performed the stabilizing function and made large profits. In the buffered specialist system the new investors could also deal with the specialist. But he too would exact a penalty as they sought to shift their holdings.

Since we don't require the markets to accommodate fully our investors in the sense that desired and actual holdings are brought into line, one can say that particularly large orders don't have a very disturbing in-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

fluence on the market because they are disregarded. However, looking at the proportion of ex ante orders cleared, this cannot have been a significant effect. The proportion of ex ante orders cleared does not vary greatly as the "scale" or number of the investors is changed. The market doesn't seem to be very rigid and it does respond to the orders that are placed.

The recent SEC study on institutional investors concluded that aggregate institutional trading doesn't cause the wide fluctuations in stock market prices that many people feared (50). Thus, our simple model is not at variance with the real world in that respect.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 7 : Equity Finance and the Allocation of Physical Capital in a Simulation Model

In the previous chapters the price series for a stock was generated as a result of trading by individual investors under certain market arrangements. The quantity of stock available was constant and only an exchange economy was described wherein investors exchanged assets.

Now a simulation model will be developed which includes a corporate sector with two firms. These firms will have investment opportunities which they shall try to finance through recourse to the stock market for capital funds. The conditions on which funds are made available to the firms by the market will affect the amount of investment undertaken. The firms shall differ in the real risk connected with their physical capital. The rate of return on physical capital for one firm will be deemed to be a normally distributed variable with a certain mean and variance. The rate of return for the second firm will be normally distributed with the same mean but difference variance. For the investors superimposed upon the real risk will be the market-generated risk associated with different trading patterns and market arrangements.

Corporate Behavior

At a point in time a corporation is faced with the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

decision of whether or not to undertake capital investment. The amount of the investment has to be decided; this will be done after consideration of the corporation's objective and its resources. Put another way, investment will be undertaken if it increases the corporation's maximand and is feasible within the framework of the corporation's constraints. If the decision to invest is made, a choice of financing methods is generally open. The corporation can use retained earnings, cash flow from depreciation, borrowed funds, or increased equity to finance the capital outlay.

We postulate that the objective of the firm should be to maximize the economic welfare of its owners. Maximizing the economic welfare of the owners is equivalent to maximizing the utility of their consumption over time. What should the goal of the firm be in order to aid the owners in achieving their objective? The view that is generally accepted is that the firm should maximize the market value per share of its stock. Then, with their wealth maximized, the owners can adjust their funds flows in such a way as to optimize their consumption by buying and selling or borrowing and lending in the market. Where there are imperfections in the capital markets it may not be possible for an owner to adjust his income stream to his preferred consumption level. If an individual shareholder could not buy or sell or borrow or lend on his own

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

account, he would then not be able to move in the direction required for optimal consumption. Then, to enhance this shareholder's welfare, the firm might have to consider a modification of its dividend payout policy. For the firm with multiple owners, this would doubtless lead to conflicts of interest. Consequently, it is better to postulate the firm is meeting the interest of most of its owners if it maximizes the value of its shares. The need for a valuation model is now apparent. If the firm is to maximize the value of its shares, its managers, who make its financial decisions, must know or at least assume the factors upon which market price depends and the way in which each operates. Otherwise, they would lack a criterion for their decision-making.

For the purposes of the simulation model it will be useful to assume that the only potential source of funds for the two firms in the model is equity financing. If we are to investigate the impact of the stock market on physical capital allocation, we should postulate a strong link between the stock market and capital investment. If the firm is allowed to use retained earnings and borrowed funds, the link will be weakened and the analysis more difficult. As a concomitant of our assumption, it follows that the firm's retention rate is zero and all earnings are paid out in dividends. The valuation model for the firm's share is simplified. The value of a share should be equal to the discounted sum of the dividend flows.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The valuation formula for the firm's shares with a zero retention rate is $V=rA/k$, where r, A, and k are the rate of return on the firm's assets, the assets per share, and the discount factor. It follows that the value of the share will increase if the earnings per share rise. If the rate of return on new investment is greater than the firm's cost of capital (in this case the earnings-to-price ratio at which new stock can be sold), the firm will raise earnings per share by undertaking the investment.

If the firm had an unlimited amount of investment it could make which would give it a return greater than the market discount factor, the total value of the firm would approach infinity. It is usual to make the rate of return a decreasing function of the size of the firm; so that as the firm increases its assets, the investment opportunities open to it become less attractive. Such an approach is somewhat complicated. Instead, in the simulation model we shall assume that the firms have a limited amount of investment to undertake; but the return on the investment does not vary with total assets. We shall place a limit on the growth of the firms by placing a limit on their total assets.

Investor Behavior

In a three-asset model we need the appropriate diversification formula for a portfolio. The three

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

assets are two corporate stocks and a riskless asset with a positive rate of return. Let a_1, a_2, and a_3 be the proportions of his wealth which an investor seeks to invest in each asset, respectively. Then, $a_1+a_2+a_3 = 1$; so $a_3 = 1-a_1-a_2$. Recall that the investor is seeking to maximize $E(R)-bE^2(R)-b\sigma_R^2$, where R is the rate of return on the portfolio. For three assets,

$$E(R) = a_1\mu_1 + a_2\mu_2 + (1-a_1-a_2)\mu_3$$

where μ_i is the expected return on the ith asset. The variance for a three-asset portfolio is

$$\sigma_R^2 = a_1^2v_1^2+a_2^2v_2^2+a_3^2v_3^2 + 2a_1a_2v_{12} + 2a_1a_3v_{13}+2a_2a_3v_{23}$$

where v_i^2 is the variance of return for the ith asset and v_{ij} is the expected covariance in the returns of asset i and j. Since the third asset is riskless, we have that v_{13}, v_{23}, and v_3^2 are zero.

The maximand for the investor is

$$a_1\mu_1+a_2\mu_2+(1-a_1-a_2)\mu_3 - b\left[a_1^2\mu_1^2+a_2^2\mu_2^2+(1-a_1-a_2)^2\mu_3^2+2a_1a_2\mu_1\mu_2 \right.$$

$$\left.+2a_1(1-a_1-a_2)\mu_1\mu_3+2a_2(1-a_1-a_2)\mu_2\mu_3\right] - b\left[a_1^2v_1^2+a_2^2v_2^2+2a_1a_2v_{12}\right].$$

Equating the partial derivatives with respect to a_1 and a_2 equal to zero,

$$0 = \mu_1-\mu_3-2b\left[a_1\mu_1^2-2(1-a_1-a_2)\mu_3^2+2a_2\mu_1\mu_2+2(1-a_1-a_2-a_1)\mu_1\mu_3 \right.$$

$$\left.-2a_2\mu_2\mu_3\right] - b\left[2a_1v_1^2+2a_2v_{12}\right].$$

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

$$0 = \mu_2-\mu_3-2b\left[a_2\mu_2^2+2(1-a_1-a_2)(-1)\mu_3^2+2a_1\mu_1\mu_2-2a_1\mu_1\mu_3 \right.$$
$$\left. +2(1-a_1-a_2-a_2)\mu_2\mu_3\right]-b\left[2a_2v_2^2+2a_1v_{12}\right].$$

The equations become

$$a_1\left[2b\mu_1^2+2b\mu_3^2-4b\mu_1\mu_3+2bv_1^2\right]+a_2\left[2b\mu_3^2+2b\mu_1\mu_2-2b\mu_1\mu_3-2b\mu_2\mu_3 \right.$$
$$\left. +2bv_{12}\right] = \mu_1-\mu_3+2b\mu_3^2-2b\mu_1\mu_3$$

$$a_1\left[2b\mu_3^2+2b\mu_1\mu_2-2b\mu_1\mu_3-2b\mu_2\mu_3+2bv_{12}\right]+a_2\left[2b\mu_2^2+2b\mu_3^2-4b\mu_2\mu_3 \right.$$
$$\left. +2bv_2^2\right] = \mu_2-\mu_3+2b\mu_3^2-2b\mu_2\mu_3$$

These are of the form

$$a_1A + a_2B = C$$

$$a_1B + a_2E = F$$

The solutions are

$$a_1 = \frac{CE - BF}{AE - B^2}$$

$$a_2 = \frac{AF - BC}{AE - B^2}$$

We must now describe how investors will arrive at the expected returns, variances, and covariance between the two stocks. For the expected returns and variances, the approach is simple: Each investor "type" will use the same formulas that were used before and described in Chapter 3. (We shall not have the investors anticipating the corporations' equity financing. The investors will be

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"surprised" when they occasionally find that assets per share have increased.) How shall investor "types" calculate the expected covariance in the rates of return on the two stocks? Each investor will have available the expected returns which he develops in his own inimitable fashion. Then, he shall use a Koyck adjustment procedure to develop the expected covariance. The expected covariance will be a weighted function of last period's actual covariance and last period's expected covariance. Last period's actual covariance will be calculated as product of actual returns minus product of expected returns.

Market Arrangements for Sale of New Stock

To finance their capital investments the firms shall enter the stock market as prospective sellers of new stock. If we were to posit that the investors correctly perceived the investment opportunities available to the firms, the firms should have no trouble in selling their stock. But this would be assuming away the problem. The question we want to answer is: Do the arrangements of the marketplace and the adaptive behavior of the investors permit equity financing by the corporations on favorable terms? Since the firms can't rely on correct anticipations by investors, should they then heedlessly sell new stock in the market even if this is driving the price down and increasing the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

cost of capital? Once a downtrend is started, the price of the stock might continue to fall to an unreasonable level. And a policy of equity financing which depresses the price of a stock will not endear management to shareholders.

In the simulation model firms will sell new shares only if the price of their stock is rising and above $150. In this way they shall not sell during price declines and at price levels far below the initial price of $199. Any sales which they do make through the market will conflict with the specialists' desire to reduce their position in a stock as it moves up. Hence, we shall have to modify the model to accommodate both the specialists and the equity-selling firms. Consequently, we shall modify the specialists' behavior on upticks. Instead of having them sell up to 50% of their holdings on an uptick, the maximum proportion will be 25%. This will leave "room" for new shares to be sold and will allow some adjustment to be made in the specialists' positions.

How much stock will the firms desire to sell? If they retained all their earnings, they could on the average increase their assets by two-tenths of a percent every period. In the model they will pay out all their earnings as dividends and will seek to sell enough shares

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

to increase their assets by one percent per period. In other words, investment opportunities materialize at that rate. Once an opportunity is missed, it is lost and the firms cannot make it up by selling more shares in the future and capturing lost opportunities through a faster rate of physical capital investment.

Evaluating Allocational Efficiency

After a period of two years (100 simulation periods), the simulation run will end and we will need some way of comparing different situations which may exist as of the end of the simulation run.

In any particular situation at the end of the two-year period, the real wealth of society will consist of a riskless asset (savings deposits) and the physical capital stocks of the two firms. A way must be found to make these assets commensurable and to compare effectively different terminal situations where the amounts of each of the assets may differ.

The proposed measure is to calculate the expected utility value to the investors of the assets after taking the real risk into account. In the model the investors have the same coefficient of risk preference. For a single unit of each asset the expected utility of that ith asset will be calculated to be

$$E(U_i) = E(Ri) - bE^2(R_i) - b\sigma^2_{R_i} \quad .$$

The utility derived from a particular asset will be the total amount of the asset, A_i, times the utility per unit,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

or $A_i E(U_i)$. Finally, the total utility to society of the terminal asset stock will be the sum of the utility from each asset or

$$TU = \sum A_i E(U_i) .$$

With this measure it will be possible to compare different terminal situations.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 7-1: Common Structural Elements of Simulation Runs 30 to 39

Model Parameters

Market clearing system: Buffered clearing with Specialist

Coefficient of risk preference = 1.5

Number of investors = 6 Retention rate = 0.

Adjustment coefficient for investors, $\gamma = .35$

rate of return on assets for firm 1 = .10 + u(i)

rate of return on assets for firm 2 = .10 +2u(i), where

u(i) has mean zero and variance 1/900.

There are two firms -- each desiring to increase its assets by 1% over previous period's. They will sell stock on an uptick provided price was above $150.

Initial Conditions

	Price/share	Assets/share	Shares outstanding
Stock 1 :	199.	100.	700.
Stock 2 :	199.	100.	700.

Each investor holds 100 shares of each stock and $19900 in savings deposit for an initial net worth of $59700.

Each specialist holds 100 shares of the stock he is specializing in and $19900 for an initial wealth of $39800.

Investor Types:

1. Fundamentalist One : Koyck weight of 0.1
2. Fundamentalist Two : Koyck weight of 0.05
3. Technician One : Koyck weight of 0.1
4. Technician Two : Koyck weight of 0.4
5. Techno-Fundamentalist : combination of Fund. 2 and Tech. 2
6. Destabilizing Fundamentalist : characteristics of Fund. 2. Signals obtained by comparing P_{t-1} with P_{t-4}.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 7-2 : Different Structural Elements of Simulation Runs 30 to 39

Run 30 : maximum permissible price change, χ=.10
Set A disturbances used.

Run 31 : Same as Run 30, except that Set B disturbances used.

Run 32 : Same as Run 30, except that χ=.05

Run 33 : χ=.05
Set B disturbances used.

Run 34 : Same as Run 30, except that Technicians' parameters have changed. Koyck weight for Technician One is 0.3 instead of 0.1; for Technician Two 0.5 instead of 0.4 .

Run 35 : Same as Run 34, except that Set B disturbances used.

Run 36 : Same as Run 30, except that initial wealth of Specialists has increased. Each specialist starts off with 150 shares of stock and $29850 for a total wealth of $59700.

Run 37 : Same as Run 36, except that Set B disturbances used.

Run 38 : Same as Run 30, except that Fundamentalists' parameters have changed. Koyck weight for Fundamentalist One is 0.2 instead of 0.1; for Fundamentalist Two it is 0.1 instead of 0.05

Run 39 : Same as Run 38, except that Set B disturbances used.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Highlights of Runs 30 to 33

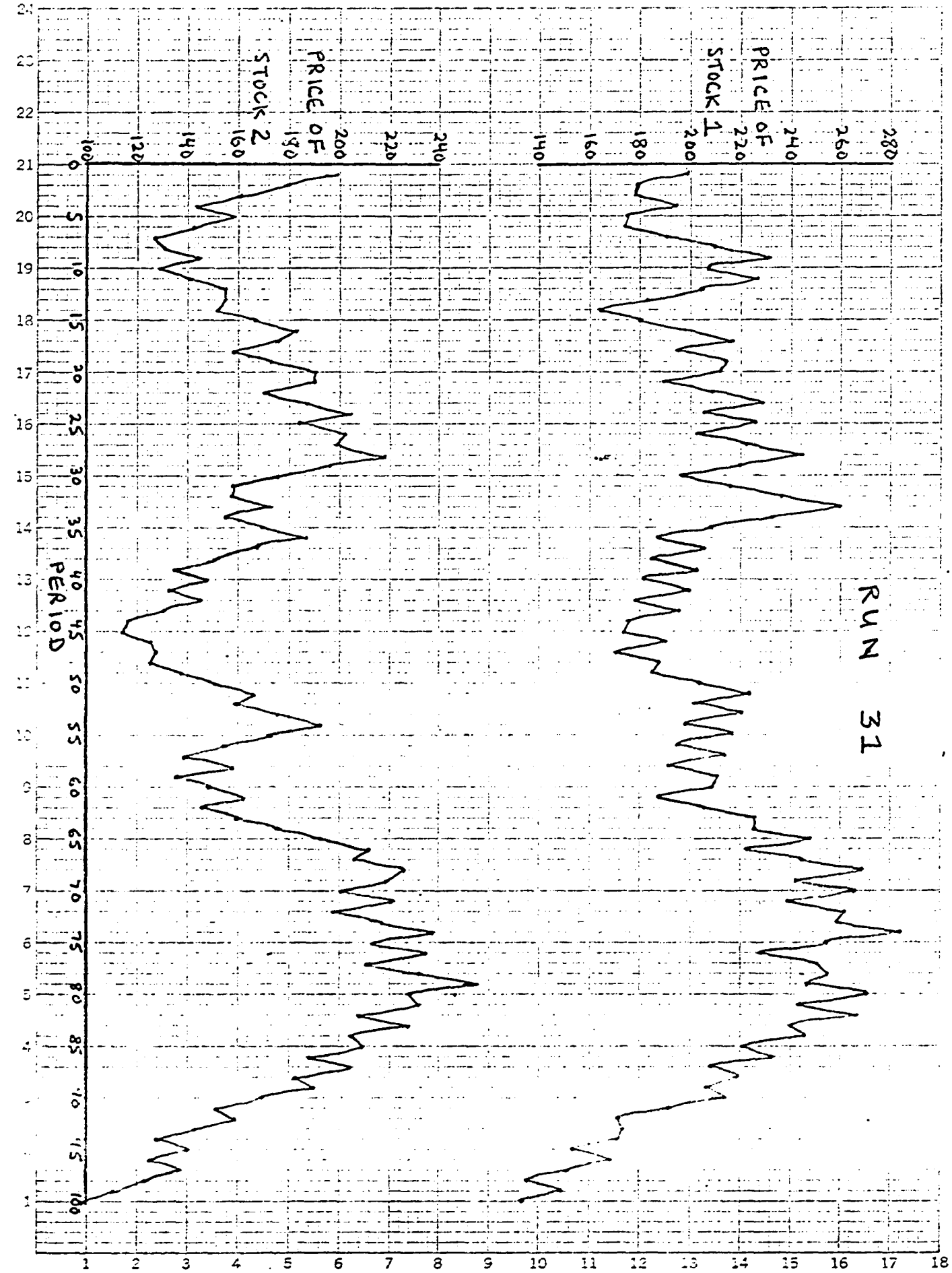
The results of Run 30 have been discarded, because the valid ranges for the utility function were exceeded and absurd results obtained. With two stocks in the model, it may be somewhat easier for trouble to arise on this account. Investors may seek to dump one of the stocks and concentrate on the other, thereby making it difficult for specialists to stabilize the market in either of the stocks.

In Run 31 a different set of Gaussian deviates was used to provide the disturbances. The total assets for Firm 1, the firm with the smaller disturbances in the rate of return on assets increased much more than the total assets for Firm 2. Remember that the firms sell new stock on an uptick and only if the price is above $150. A look at the price chart for Run 31 will show that Stock 1 was in a more favorable price range for equity financing than Stock 2. Since Firm 1's cost of capital was lower, it wound up with more assets per share than Firm 2.

Results of Run 31:	Stock 1	Stock 2
Final Price	134.	98.
Total Assets	111220.	92998.
Percentage Change in Assets	59%	33%
Total Shares Outstanding	884	817
Assets per share	125.81	113.83

Total Expected Utility of Real Final Wealth : 23347.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Although it would be possible to discuss many aspects of this and the following simulation runs, the discussion will focus on the allocation of physical capital within the framework of a two-stock model. Such questions as the relative performance of the investors and the price patterns generated could be examined; but they are incidental to the purpose of this section and will be but briefly touched upon.

In Run 32 a 5% limit was placed on period-to-period price changes. Unlike Run 30 the price fluctuations were moderate and there was no trouble from the utility functions.

Results of Run 32:	Stock 1	Stock 2
Final Price	252.	238.
Total Assets	119147.	117490.
Percentage Change in Assets	70%	68%
Total Shares Outstanding	905	925
Assets per share	131.7	127.0

Total Expected Utility of Real Final Wealth : 24505

The two firms managed to increase their assets by substantial amounts. The less risky firm did slightly better than the more risky one. In a favorable price environment both firms were successful in conducting equity financing.

In Run 33 disturbance set B was used with a 5% price limit. In comparison with Run 31 where there was a 10% limit, Firm 1 did about as well; but Firm 2 did much better. Since the price pattern in Run 31 was unfavorable

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

to Firm 2, the better price environment brought about by the 5% limit had a beneficial effect on its equity financing.

Results of Run 33:	Stock 1	Stock 2
Final price	142.	111.
Total assets	110470.	100270.
Percentage change in assets	58%	43%
Total shares outstanding	893	857
Assets per share	123.7	117.0

Total expected utility of real final wealth : 23569

Highlights of Runs 34 to 37

In Runs 34 and 35 the technicians' parameters were changed so that both adapted faster. This created trouble with the utility functions, so both these runs were discarded.

In Runs 36 and 37 the specialists are given larger initial resources. If they are able to buffer the price series, this may enhance the ability of firms to sell new stock. Price declines below $150 will be less likely to occur. However, the specialists may interfere with the sale of nes stock on upticks, since they have larger positions to dispose of.

Results of Run 36:	Stock 1	Stock 2
Final price	169.	155.
Total Assets	110316.	101321.
Percentage Change in assets	58%	45%
Total shares outstanding	917	880
Assets per share	120.3	115.1

Total Expected Utility of Real Final Wealth : 24681

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Results of Run 37:	Stock 1	Stock 2
Final price	200.	136.
Total assets	114721.	96501.
Percentage change in assets	64%	38%
Total shares outstanding	921	861
Assets per share	124.6	112.1

Total Expected Utility of Real Final Wealth : 24362

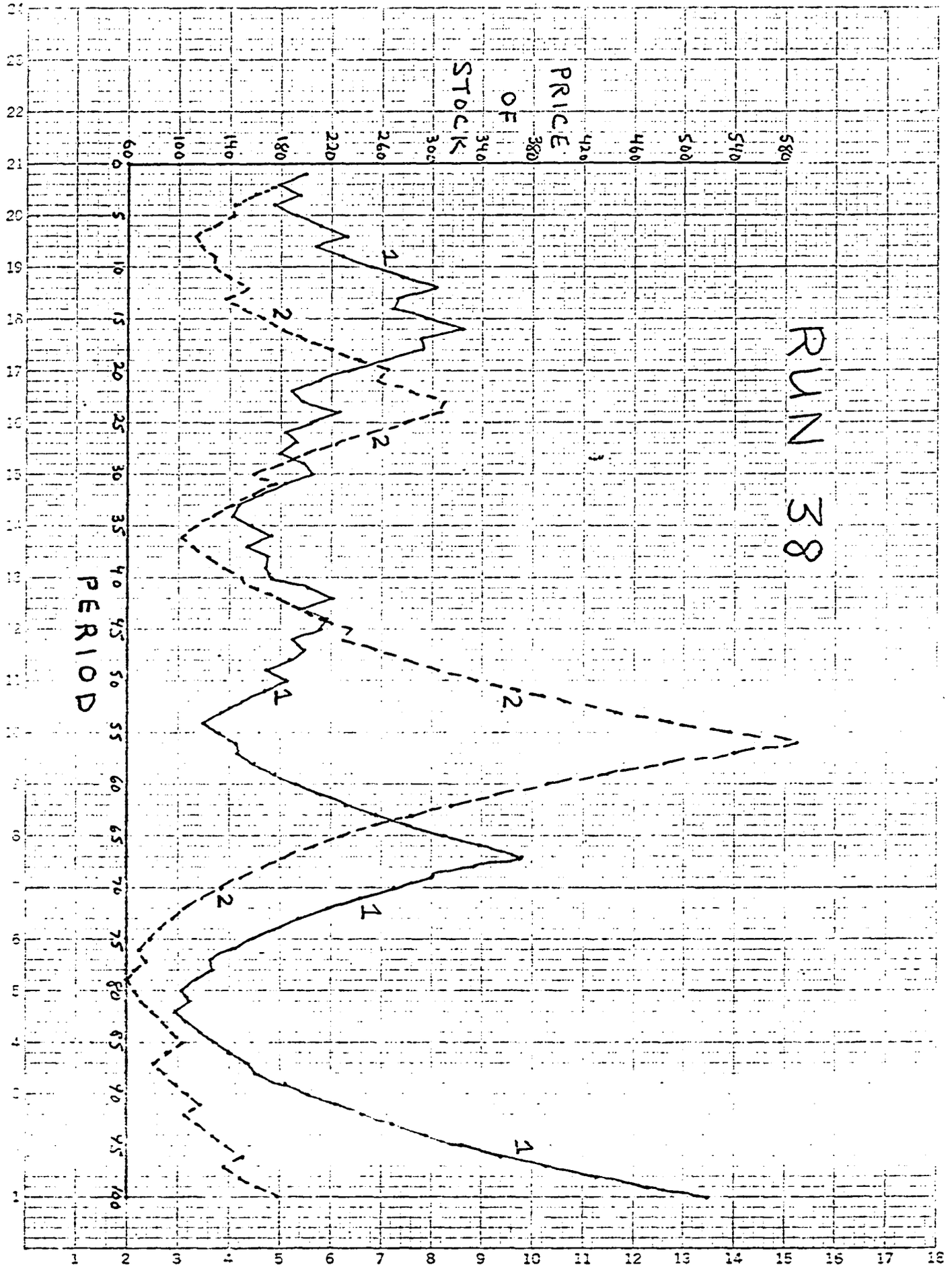
The larger resources of the specialists did prevent trouble in Run 36 on account of the utility functions; whereas in Run 30 with similar conditions the simulation had to be discarded. Other than that, the larger resources of the specialists seem to have had a slightly beneficial effect on equity financing. But most of this is due to the fact that some of the new shares were eventually absorbed by the specialists.

Highlights of Runs 38 and 39

In Runs 38 and 39 the parameters of the Fundamentalists were changed, so that they adapted faster in their expectations formation. In Run 39 this resulted in trouble with the utility functions so that run was discarded.

The price fluctuations in Run 38 were tremendous. Stock 2 had a rising stretch from period 36 to 56, during which its price went from 103 to 590. During most of this stretch Firm 2 was able to sell new shares on favorable terms. (It sold shares on an uptick when the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.



Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

price was above $150.) However, during the subsequent decline the firm could not sell any stock, and it did no more financing until period 100. Firm 1's price fluctuations were also large.

In Run 38 a "separation of markets" phenomenon was very much in evidence. Certain investors invested exclusively in one of the stocks and cash. Instead of diversifying and holding both stocks, many investors concentrated on a single stock. It is not hard to see how this can happen. If stock A is going up, Technicians will be attracted to stock A and will sell stock B. As Stock A rises, fundamentalists will sell stock A to the technicians and will buy stock B which is falling below its normal price. Soon, technicians will hold a large part of the A stock outstanding. If they still have cash reserves, they will seek to increase their holdings of stock A, pushing up the price further. The price will keep on rising. Three factors can bring a halt to the price rise : equity financing by firm A may deplete the cash reserves of technicians and eventually reverse the price rise (assuming technicians can't get credit on the basis of their stock holdings); the proportion of their total wealth invested by the technicians in A will be approaching one and there may be some tendency to diversify when this happens; as their wealth increases tech-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

nicians might feel so well off that they will want to consume more by realizing part of their wealth (this cannot occur in the model since there is no consumption).

Results of Run 38:	Stock 1	Stock 2
Final price	520.	179.
Total assets	113068.	90826.
Percentage change in assets	62%	30%
Total shares outstanding	877	781
Assets per share	128.9	116.3

Total Expected Utility of Real Final Wealth : 23082

In Run 38 the less risky firm again succeeded in increasing its assets by more than the risky firm.

Discussion of Chapter 7

In these last ten simulation runs we have conducted an inquiry into how the stock market affects the allocation of physical capital. The following conclusions have emerged:

1. Six of the ten simulation runs were trouble-free and gave valid results. In all six of these cases the firm with the smaller variability in the rate of return on its physical assets succeeded in securing the larger amount of equity financing and thereby increased its capital assets more. For the six runs the average increase in Firm 1's assets was 62%; while firm 2's assets increased by 43% on the average. The market-generated fluctuations do not reverse the relation of the real risk and lead to greater investment in the firm with the risky capital

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

stock.

2. A "separation" of markets phenomenon occurred in many of the runs. A portion of the investors invested exclusively in one of the stocks and cash; while another portion held the other stock and cash. The price action of a particular stock was then heavily influenced by a subset of all the investors in the model.

3. Large price fluctuations do not impair a firm's ability to engage in equity financing. A firm can still sell additional shares even if its shares are very risky. The only requirements are that the price of the shares be rising and that the price not be so low to preclude equity financing by the firm.

4. From the firm's point of view an explosively rising price pattern for its shares will enable it to increase its assets at a very low cost of capital. In such cases assets per share at the end of a simulation run would be highest. Such a view is small comfort to those investors who purchased shares near the peak and sustained losses in the subsequent decline.

5. In several cases the terminal price of the shares was below the initial price. There are two explanations for this. In the short-run the issuance of new shares depresses the price and swamps the positive effect that should be observed due to the rise in assets per share. Second, the relative proportions of the assets change: the physical assets of the firms increase sub-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

stantially, while savings deposits are reduced to finance the new investment. To induce the investors to hold the assets in the new proportion requires a change in the relative yields.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 8 : Market Structure and Market Performance

In addition to bringing buyers and sellers together, stock markets should allow for the orderly trading of securities. Although the term "orderly" cannot be precisely defined, there are several qualities which a stock market should possess. A high degree of liquidity is a desirable feature of a market. This will enable investors to alter their holdings quickly. A security will be more attractive to an investor if it can be sold easily at a predictable price. If a large quantity of an asset is offered for sale, however, it may be necessary to offer a price discount to facilitate market absorption of such an amount. An orderly stock market will also possess continuity. Continuity will insure that the price of a transaction will bear a reasonable relationship to the immediately preceding one. One requirement for insuring continuity is the prompt and complete dissemination of information on transactions. This will provide a reference point to potential buyers and sellers in succeeding transactions. A market possesses "depth" if there are adequate numbers of orders at different price levels. The degree of depth is a function of investor interest in a particular security. It can also be a function of the market participation of a specialist who is "making a market" in the stock. To engender investor confidence and acceptance of equity securities, stock markets should exhibit

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

a modicum of stability. Unreasonable and excessive fluctuations, which inter alia destroy the value of securities as collateral, should be minimized.

Our survey of stock markets around the world showed how they were organized. Of course, if the securities markets of a country are not developed, no amount of organizational structure can remedy that deficiency. Yet, markets should be designed so that trading is as orderly as possible. The countries with the least developed securities markets utilize some variant of the "call" system. Under the "call" system an exchange official calls the names of particular stocks one or more times during the course of the day, and all brokers holding orders from their customers trade at that time.

The Role of the Specialist on U.S. Exchanges

Until shortly after the Civil War the New York Stock Exchange operated as a "call" market. However, the large volume of trading induced the exchange to drop the "call" system and adopt continuous trading. In a continuous auction market, a market order is usually executed as soon as a willing party on the other side is found. There appears to be no historical data showing how the problem of continuity was handled, if at all, between the adoption of the continuous auction market and the turn of the century. Likewise, the exact time that members first became specialists is unknown. By 1909,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

however, specialists were a significant enough factor to merit mention in the Hughes Committee Report. (36, pg. 61)

What are the objectives of the specialist system? It has been the consistent view of the New York Stock Exchange, expressed on many occasions and under different circumstances, that liquidity and continuity are the prime indicia of the quality of the market. (36, pg. 78) The NYSE also intimates in some of its public statements that part of the specialist's function is to "stabilize" the market. The Exchange pamphlet entitled "Now About the Specialist", says (36, pg. 96):

> Moreover the vast majority of the specialist's transactions for his own account is made against the trend of the market. Because he has the responsibility of filling in gaps in supply and demand, the specialist finds himself buying when the market is falling and others want to sell, and supplying stock when the market is rising and others want to buy. Approximately 85 percent of the specialist's dealer transactions are stabilizing in nature. Specialists thus play a vital role in keeping price changes between transactions narrow and in maintaining the broad liquidity of the exchange markets.

On other occasions exchange officials have insisted that specialists have nothing to do with stabilization as that word is commonly understood, i.e. pegging or fixing prices near a certain level. An exchange vice-president in charge of the floor department testified that the comments made in floor department memoranda with respect to "retarding declines" are indicative of nothing but the duty to maintain price continuity. He explained the use of such language as a"matter of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

semantics." He further testified (SEC Report, 36, pg. 98):

> Q. Do you think the specialist has an affirmative duty to the best that he can within the limitation of his capital ability to retard or halt the decline in the price of a stock?
> A. I don't think the specialist has any duty to halt the decline. That is not possible. He is to do the best he can to maintain continuity on the way down within the realm of practicality.

* * * * *

On United States stock exchanges it is the function of the specialist to determine the prices of transactions. This has led to concern that the specialist may unduly influence the course of prices or that he may exploit his position for his personal gain. The specialist is permitted to trade for his own account and, in his order book, where he maintains a record of unexecuted limit and stop orders, he possesses information which is not available to other investors. In a particular stock the situation may be as follows: the last transaction took place at a price of 35; the specialist has a limit order to buy the stock at 33; he also has a limit order to sell the stock at 35¼. Thus the spread between the bid and asked orders as represented by the orders in the specialist's book is very wide. A market order to sell is now received at the trading post. The specialist can now execute the order at 33, or he can buy the shares for his own account at some price above 33. Let us say he bought the shares at 33¼. By doing this, he gave the seller of the shares a better price than the limit order of 33; but

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

he prevented the investor with the limit order from getting the shares at the "bargain" price of 33. Now, assume he receives a market order to buy the shares. He can sell the shares from his own account to the buyer at 35. What has been the result of the specialist's actions? Without his intervention the series of transactions would have been 35, 33, 35¼. With his intervention the series is 35, 33¼, 35. Thus, the specialist has provided greater "continuity" in the price series. In the process he made a profit of $175 for himself. If he had to dispose of the stock, he could have done it at a price of 33, incurring a loss of $25. Thus, the risk he took seems small in comparison with the gain. Of course, there is no presumption that specialists will act in such an extreme profit-maximizing fashion. The series of transactions could just as well have been 35, 34¼, 34½. On the other hand, if the specialist cumulated the two orders he could have crossed them at a common price of 35, say. For providing instant "liquidity" to sellers of a stock the specialist can exact a price. In actively traded issues large profits can be made by the specialist. If market orders to buy and sell are roughly in balance, the specialist could execute most of the sell orders at 40 say, and most of the buy orders at 40¼, thus making a ¼ point profit on each round lot. If he does this for 50 round lots a day, his profits would amount to $1250.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

It seems that in inactive issues where specialist participation may be most needed, the risks are greatest for the specialist, while the chances of trading profits are lower, so that the specialist's incentives for making a close continuous market are reduced. Conversely, the more active the issue, the greater the specialist's economic incentive to carry the concepts of liquidity and continuity as far as possible. The depth of the book and the volume of general activity provide means for liquidation by the specialist, thereby limiting his risk; while the turnover assures continuous profit from the "jobber's turn". There seem to be at least three ways for dealing with any abuse of the specialist function for specialist gains in his personal interest. One way is to have competing specialists in every issue. A second is to auction off specialist positions and capture the "economic rents". A third way would be to have the exchange or some public body perform the specialist function. These methods are not without their drawbacks. Several small specialist firms might provide less liquidity and continuity than one large one. If specialist positions are auctioned off, then this might lead to extreme profit-maximizing behavior on the part of specialist units as they sought to reap their investment. Thirdly, the stock exchanges are not public institutions but associations of private individuals. And the present specialist system is an important source of income to at

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

least some of the exchange members. Both the exchanges and the Securities and Exchange Commission monitor and regulate the conduct of specialists and there are restrictions placed on specialist behavior. He could not, for example, open a stock at a price lower than the preceding day's closing price if he had more buy than sell orders at that price. The specialist is also prohibited from "stretching across" his order book and touching off orders and thereby creating fluctuations.

The SEC report provides figures on the specialist participation rate or "SPR". This is the percentage of volume in which the specialist participated as either buyer or seller. Specialists from 1937 to 1953 had an aggregate SPR ranging from 15.5 percent to 21.2 percent. Starting in 1954, the SPR increased sharply until it exceeded 29 percent in 1959, 1960, and 1961. Naturally, the degree of necessary participation varies with different stocks, depending upon such things as activity, the thickness of the specialist's book, and the price trend. In the big well-known stocks like General Motors and Standard Oil of New Jersey, public activity is sufficient so that the specialist doesn't have to participate very much, say in only 5% of the transactions. However, in stocks where the public is not so active, the specialist may have to deal in 40% of the transactions. Despite this tendency, some specialists have high participation rates in active stocks. For example the SEC

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

found that during three weeks it studied, in 17 percent of the instances in which volume was over 10,000 shares a day, specialists had an SPR of more than 45 percent. The report stated that participation seems to be as much a function of individual attitude and capital of the specialist units as it is of the qualities of particular types of issues.

A high SPR, however, is not necessarily indicative of stabilizing activity. The explanation, of course, is the phenomenon of intra-day trading by specialists in the real world. Two examples from the SEC report will illustrate. By the close of business on Friday, May 25, 1962, specialists had a net long position of 2,400,000 shares. On Monday, May 28, 1962, when the Dow-Jones Industrial Average declined 34.95 points or 5.7 percent, specialists purchased on balance 206,400 shares. On May 28 specialists bought and sold 3,093,220 shares and the net purchase balance represented only 6.7 percent of those purchases and sales. Also, volume for the day was 9,819,560 shares of which the specialists' purchase balance represented only 2.1 percent. The SPR however was about 31.5%. On September 26, 1955, the first trading day after President Eisenhower's heart attack, the DJIA fell 31.89 points or 6.5 percent. On that day in 1955, specialists' net balances reflected a more significant part of the overall picture. They bought and sold 2,923,170 shares and their net purchase balance of 595,550 shares represented 20.4 percent of their purchases and sales. Reported volume was 7,761,000 shares and the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

specialists' purchase balance represented 7.6 percent of that total.

A crucial determinant of the specialists' ability to maintain orderly markets is their capital resources. NYSE specialists employed $69,099,000 in 1959 and $76,-285,000 in 1960 of capital in their business. This would be an average of $628,000 per specialist unit in 1959 and $693,500 per unit in 1960. The variation among the units is significant: most units were clustered at the lower end of the scale, while those in the upper 10 percent of the scale had over 50 percent of all specialist liquid capital. The data also indicates a relationship between the number of common stocks per unit and the capital. Thus, the top 10 percent of units with the most capital used in carrying positions (during 1960) had 218 common stocks assigned to them (in 1961), averaging $193,800 of capital per common stock. Those units comprising the bottom 10 percent of units in the amount of capital had 80 common stocks and averaged $6,370 per common stock. (36, pg. 70) The 1963 SEC report recommended that the capital requirements for specialist units be increased (36, pg. 168):

> The NYSE should increase its specialist capital requirements in recognition of current market needs and specialist obligations.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

> Instead of the present requirement of capital sufficient to carry 400 shares of stock in which a specialist is registered, the nature of the market in most securities would seem to require that specialists have the capital ability to carry at least 1,200 shares, and preferably a higher amount such as 2,000 shares of each issue; the exact figure or figure (sic) may be left for future definition by the Exchange and the Commission jointly.

Although increasing the capital requirements of specialists may be conducive to greater continuity, it does not seem feasible for the specialists to stabilize the market to any degree. We have already discussed the behavior of specialists during the market break of May 28, 1962, when the Dow-Jones Industrial Average declined by 34.95 points. The SEC report concludes (36, pg. 114): "Taxed by events and facing probable losses by price declines so rapid as to wipe out the trading advantages of the spread, most specialists, not surprisingly, were unwilling to undertake the role of market stabilizers." An examination of trading in AT&T during that day will help to illustrate the point (36, pg. 115):

American Telephone & Telegraph
on May 28, 1962

Close(May 25, 1962)	112.625	Reported volume	282,800
Open (May 28, 1962)	109.25	Specialist:	
High for day	109.75	Opening position long	600
Low for day	100.25	Purchases	21,400
Close(May 28, 1962)	100.625	Sales	20,500
Net change	-11.00	Closing position long	1,500

Thus, the specialist added only 900 shares to his holdings during the day. Whether additional purchases by the specialist would have stemmed the decline is a

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

moot point. Even the commitment of $1 million, sufficient to purchase about 10,000 shares, would have been a small amount compared to the trading volume in the stock.

The continuity and liquidity of an exchange market ultimately depend on the depth of public participation and the extent to which that can be, and is, supplemented by specialist participation. One realistic objective of the market would seem to be to provide "price continuity with depth", i.e. a market which moves in small fractions but in which the specialist stands ready to make reasonable capital commitments at each significant price level. An extreme example of price continuity without depth may serve to illustrate the point (36, p. 124):

Summary of the Price Changes of Columbus & Southern Ohio Electric

	Volume	Open	High	Low	Close	Change
May 28, 1962	3,000	62	62	60	60	-2
May 29, 1962	6,700	57½	57½	39½	49.75	-10.25
May 31, 1962	9,200	60	61	59½	60	10.25
June 1, 1962	2,100	59¼	59¼	57.75	58½	-1.50

The stock opened on May 29 at 57½, down 2½ from the previous close. Within an hour and thirty-nine minutes after its opening, and after only 4,300 shares had been traded, the stock had declined to 39½, a drop of one-third in price. Of the 4,300 shares traded, the specialist unit purchased 4,100. The variations between sales were one-half

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

point from the opening to 46½; thereafter the variations were 1 point. After reaching the low of 39½, the price increased on 1 point variations between sales up to about 47, and thereafter on smaller variations to the closing price of 49.75 . The absence of practically any buy orders during the decline was noted and the specialist absorbed most of the sell orders. If the specialist had doubled the size of his bids, however, and added depth to the market the price decline should have been substantially less. Furthermore, rather than permit such gyrations in the price of a high caliber utility stock, the specialist could have consulted a governor of the Exchange and halted trading in the issue.

The Initial Version of a Liquid Specialist Clearing System

To examine whether the institutional arrangements of the market can have a substantial effect on the course of securities prices it will be useful to construct a third type of clearing system. The orders of the investors will arrive randomly at the trading post and each order will be handled separately. This type of clearing system will be called the liquid specialist system. The investor will usually find that at least part of his order will be executed. Thus, the specialist will enable investors to liquidate at least part of their portfolio instantly (except for a qualification dealing with the price) and to add to their portfolio (with a similar qualification

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

regarding price).

If specialists in the real world were bound by predetermined rules, it would be possible to structure the liquid specialist model according to those rules. On the New York and American stock exchanges the specialists are enjoined to maintain an "orderly" trading market in the stocks for which they are responsible. Under this injunction the specialists have a wide degree of latitude for the exercise of their judgment and discretion in carrying out their function. Of course, the specialists' behavior is monitored by regulatory bodies and he may be reprimanded, replaced, and penalized if he abuses his privileged position.

In designing the behavior of tne liquid specialist clearing system for the simulation model, cognizance was taken of the four objectives of liquidity, continuity, depth, and stability. Continuity was achieved by requiring that each transaction be cleared at the preceding price or an ε% deviation from the preceding price, where ε is the continuity parameter. The depth objective was settled by allowing the specialist to use at most, either ρ% of his cash or ρ% of his shares for each transaction, where ρ is the depth parameter. Maximum permissible period-to-period price changes were set at χ%. At the time of the placing of his order an investor could not be certain at what price it would be executed. Every investor places

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

an order at the beginning of each period and they arrive in a random sequence at the trading post. Thus, if the first four orders to arrive at the trading post were sell orders, the price might decline by 4ε%. If the fifth order were also a sell order, it would not be executed if that entailed going beyond the χ% limit. If buy orders are interspersed with sell orders, the χ% boundaries may not be reached. The specific instructions under which the liquid specialist will operate are:

1. The specialist's initial share holdings will be designated the "target" number of shares. At any time during the simulation, his actual holdings will differ from this "target" number.

2. If a buy order for a certain number of shares arrives at the trading post, the specialist will

2a. execute the entire order at the previous transaction price if his stock holdings after the execution will exceed or equal the "target" number of shares; or

2b. execute the order at the previous transaction price plus ε%. The specialist will not dispose of more than ρ% of his shares to take care of the order. If the bid volume is less than ρ% of the specialist's shares, the entire order will be executed. If not, only part of the order will be executed.

3. If a sell order for a certain number of shares arrives at the trading post, the specialist will at the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

most devote ρ% of his cash resources to absorb the sell order.

3a. If the sell order can be handled with ρ% of the specialist's cash and if his share holdings after execution of the order will be below the "target" number, the order will be executed at the previous transaction price.

3b. If the sell order cannot be absorbed with ρ% of the specialist's cash, or if it will result in adding to his holdings beyond the "target" number, or if both will occur, the transactions price will be ε% below the previous transaction price.

At no time will any order be executed at a price more than χ% away from the previous period's closing price.

Since there are many parameters in the liquid specialist system, several simulation runs were tried for various values of the parameters.

Preliminary Simulation Results with Liquid Specialist System

A model with twelve investors was developed. The investor "types" are described in Table 8-1. Other structural elements of the model are listed in Table 8-2 and the parameters and results are in Table 8-3.

The three key parameters to be watched are the price continuity parameter, ε; the maximum permissible period-to-period price change, χ; and the specialist's depth parameter

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 8-1 : Investor "Types" Used in Liquid Clearing System and All Chapter 8 Simulation Runs

1. Fundamentalist One : Koyck weight of 0.05
2. Fundamentalist Two : Koyck weight of 0.10
3. Fundamentalist Three : Koyck weight of 0.15
4. Fundamentalist Four : Koyck weight of 0.20
5. Fundamentalist Five : Koyck weight of 0.40
6. Technician One : Koyck weight of 0.10
7. Technician Two : Koyck weight of 0.40
8. Technician Three : Koyck weight of 0.50
9. Technician Four : Koyck weight of 0.70
10. Techno-Fundamentalist : combination of Fundamentalist One and Technician Two.
11. Destabilizing Fundamentalist One : characteristics of Fundamentalist One. Signals obtained by comparing P_{t-1} with P_{t-4}.
12. Destabilizing Fundamentalist Two : characteristics of Fundamentalist Five. Signals obtained by comparing P_{t-1} with P_{t-4}.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 8-2 : Other Structural Elements for Simulation Results Presented in Table 8-3

Model Parameters

Market clearing system : Liquid clearing with specialist

Coefficient of risk preference = 1.5

Number of investors = 12

Retention rate = 0

$r(t) = .10 + u(t)$, where $u(t)$ is normally distributed with mean zero and variance 1/900.

Initial conditions

Price per share = 199.

Assets per share = 100.

Each investor starts with 100 shares of stock and $9950 for a total net worth of $29850.

Liquid specialist starts with 350 shares of stock and $69650 for a total net worth of $139300.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 8-3 : Liquid Clearing with Specialist Using Disturbance Set A under Various Regimes

	Regime I	Regime II	Regime III	Regime IV
Price continuity	3%	2%	2%	2%
Limit on period-to-period price change	13%	13%	13%	9%
Depth(percentage of asset per transaction)	15%	15%	10%	15%
Total market orders (volume)	89629	89864	95269	86560
Proportion executed	.333	.321	.262	.301
Trading volume	29850	28876	24977	26020
Total number of transactions	750	846	884	722
Mean price of stock	130.4	131.1	121.5	127.8
Variance of stock prices	382.2	473.2	474.5	491.1
Percentage change in specialist's wealth	-44.3	-57.3	-48.9	-47.6
Percentage change in total wealth	-3.2	-5.7	-8.8	-6.7

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

(percentage of asset to be used per transaction), ρ. The results under the four regimes are very similar. Regime I produced a smaller variance in stock prices and executed a higher proportion of *ex ante* orders (measured by volume). When price continuity was improved, as in Regimes II and III, this resulted in a greater number of transactions. But trading volume in Regime II was about equal to trading volume in Regime I. In Regime III the total of *ex ante* orders increased but the proportion cleared declined. With the low depth parameter of Regime III many investors probably reentered part of their unsatisfied orders in subsequent periods.

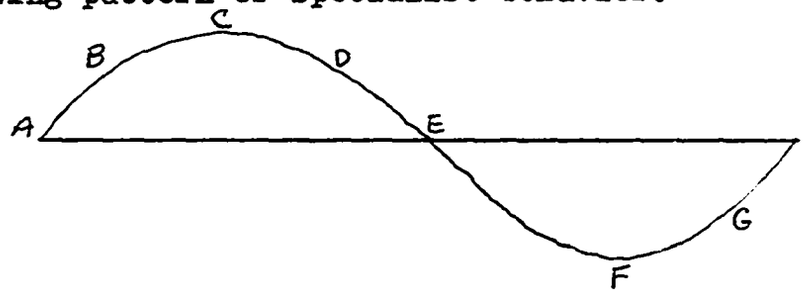
One disquieting feature of all four regimes is that the liquid specialist incurred large losses. This is not a very viable clearing system then, since it seems to lead to its own demise.

Second Version of a Liquid Specialist System

The initial attempt to structure the liquid specialist's behavior produced large losses for him. It is essential to understand why this occurred so that we can construct a set of rules which will produce acceptable profits for him. An early set of behavior rules for the specialist had him using at most 15% of his cash balance for each market sell order. Since each investor in the model might place a market order each period, it was

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

necessary to spread the specialist's resources over all the market orders. Over a cyclical fluctuation, the 15% rule produced losses for the specialist. Consider the diagram below. The 15% rule would result in the following pattern of specialist behavior.



From A to B : specialist sells most of his stock holdings to investors; accumulates cash.

B to C : specialist sells some more of his shares to investors; accumulates more cash; but absolute number of shares sold to investors less than from A to B.

C to D : specialist buys shares heavily; runs down cash balance.

D to E : specialist continues buying stock; cash balance decreases further; fewer shares bought than from C to D.

E to F : specialist buys a few more shares; cash balance becomes very small.

F to G : Since specialist has largely shifted into stock from C to F, he sells shares heavily from F to G; cash balance increases.

Thus, the 15% rule has the specialist doing most of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

his selling from A to B; buying shares heavily from C to D; and then selling heavily from F to G at a lower price.

It is clear that the 15% rule must be modified so that the specialist doesn't concentrate his portfolio changes just after the turning points. A better pattern would be to adjust the specialist's portfolio just before the turning points. However, this entails guessing where the turning points are going to be. Instead a middle position which seeks to spread the specialist's activity over the cycle was chosen.

The specialist shall start each simulation run with half of his wealth in stock and half in cash. Let's say he starts with Z shares of stock and Z dollars of cash. His behavior rules will be:

1. If a buy order for a certain number of shares arrives at the trading post, the specialist will sell a certain number of shares in an attempt to satisfy that order. In some cases the number of shares sold may not be enough and only part of the investor's order will be satisfied. How many shares the specialist sells depends on his stock holdings.

1. If specialist's stock position is, then he sells at most:

above 1.33Z	.2Z
from 1.33Z to .67Z	15% of stock position
below .67Z	25% of stock position

2. The buy order will be executed at a price at least 3% higher than the previous transaction.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2a. Investors will place "limits" on their buy orders 13% above the closing price of the previous period.

3. If a sell order arrives at the trading post, the specialist will be obliged to purchase some of the shares. How much cash he uses will depend on his cash balance.

If specialist's cash balance is,	then he uses at most:
above 1.33Z	.2Z
from 1.33Z to .67Z	15% of cash balance
below .67Z	25% of cash balance

4. The sell order will be executed at a price at least 3% below the previous transaction (rounding off to lowest dollar).

4a. Investors will place "limits" on their sell orders 13% below the closing price of the previous period.

Comparison of Market Performance with Different Clearing Arrangements

The twelve investors of Table 8-1 were used in simulations to investigate market performance with different clearing arrangements. There were three clearing systems : pooled, buffered, and the second version of liquid clearing. Each system was simulated with three different sets of disturbances. Thus, there were nine simulation runs. The structural elements of the different clearing systems are listed in Table 8-4 and the results are presented in Tables 8-5 and 8-6.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 8-4 : Structural Elements of Clearing Systems Used in Comparison Study

Elements Common to Each System

Coefficient of risk preference = 1.5

Number of investors = 12

Retention rate = 0.

$r(t) = .10 + u(t)$, where $u(t)$ is normally distributed with mean zero and variance 1/900.

Initial price per share = 199.

Initial assets per share = 100.

Each investor starts with 100 shares of stock and $9950 for a total net worth of $29850.

Pooled Clearing

Adjustment coefficient for investors, $\gamma = .35$

Buffered Clearing

Maximum permissible period-to-period price change, $\chi = .10$

Specialist begins with 260 shares of stock and $51740 for initial net worth of $103480.

Liquid Clearing

Specialist's behavior as described in two previous pages concerning second version of liquid specialist system.

Specialist begins with 350 shares of stock and $69650 for a total net worth of $139300.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 8-5 : Market Statistics with Different Clearing Arrangements

Pooled Clearing

Disturbance Set	Set A	Set B	Set C
Total market orders (volume)	64987	54879	63686
Proportion executed	.289	.272	.334
Trading volume	9376	7457	10631
Specialist trading/Trading volume	0.0	0.0	0.0
Mean price of stock	175.9	171.8	174.4
Variance of stock prices	526.8	386.1	281.1
Corr. coef. for price changes	.293	.165	.255

Buffered Clearing with Specialist

Disturbance Set	Set A	Set B	Set C
Total market orders (volume)	62942	65971	69782
Proportion executed	.772	.780	.775
Trading volume	32517	35058	35671
Specialist trading/Trading volume	.507	.531	.484
Mean price of stock	168.8	169.4	153.0
Variance of stock prices	391.0	293.9	344.0
Corr. coef. for price changes	-.110	-.268	-.213

Liquid Clearing with Specialist

Disturbance Set	Set A	Set B	Set C
Total market orders (volume)	74944	68247	76497
Proportion executed	.464	.488	.474
Trading volume	34753	33281	36279
Specialist trading/Trading volume	1.0	1.0	1.0
Mean price of stock	162.0	176.9	174.5
Variance of stock prices	389.1	437.3	353.2
Corr. coef. for price changes	-.009	-.054	.117

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 8-6 : Investor Performance with Different Market Clearing Arrangements (Percentage Change)

	Pooled Clearing			Buffered Clearing			Liquid Clearing		
	Set A	Set B	Set C	Set A	Set B	Set C	Set A	Set B	Set C
Fund. One	49.8	-4.7	73.3	46.3	3.6	19.1	74.7	70.1	50.6
Fund. Two	30.0	16.3	48.2	38.3	-17.4	-17.7	104.6	38.0	138.9
Fund.Three	25.0	26.4	-24.8	-38.9	-52.3	-48.2	19.6	3.6	-5.5
Fund. Four	37.9	9.6	-19.0	-43.6	-56.2	-50.9	35.1	60.6	14.2
Fund. Five	7.3	-5.4	41.1	-26.8	-39.1	-44.5	56.6	30.2	24.6
Tech. One	-27.3	-31.9	-41.4	-29.0	-25.4	-30.4	-66.2	-67.2	-70.6
Tech. Two	-25.9	-12.1	-36.7	-38.0	-30.0	-30.1	-79.1	-69.3	-81.9
Tech.Three	-29.4	-9.8	-44.1	-43.7	-28.8	-22.7	-73.5	-80.1	-88.0
Tech. Four	-28.0	-4.1	-43.2	-47.4	-34.2	-16.8	-73.5	-80.5	-75.0
Tch.-Fund.	23.6	1.9	47.7	10.8	-19.7	4.0	104.5	31.9	59.2
Dst.Fnd.1	19.0	5.3	3.1	8.8	-7.4	-12.7	2.6	3.2	1.9
Dst.Fnd.2	12.9	1.6	-1.2	-5.8	-35.1	-50.9	-48.8	-11.3	-50.8
Specialist				81.4	94.6	55.5	8.6	31.5	17.8
Total	7.9	-0.6	0.3	7.3	-0.9	-7.1	5.8	4.6	0.04

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

As a measure of the degree of variability under each system, we can look at the variance of stock prices. No clearing system exhibited lower variance for all three disturbance sets. The buffered clearing was slightly better than the liquid clearing. With disturbance sets A and C the two systems did equally well. The buffered system did better than the liquid clearing system with set B. The pooled clearing system had the highest variance with set A, the middle position with set B, and the lowest variance with set C.

Trading volume for the pooled clearing system was much lower than for the other two systems. With no specialist present there were many periods when no shares changed hands because all the investors were on the same side of the market. Consequently, trading volume under pooled clearing was approximately 30% of the trading volume for the other two regimes.

An additional measure of market performance would be the proportion of his orders that an investor is able to execute in the marketplace. We can cumulate the volume of all the market orders which investors place. Then of this aggregate total we can see what proportion is executed with each regime. Under pooled clearing the proportion ranged from .272 to .334; for buffered it was from .772 to .780; and for liquid clearing it was .464 to .488 .

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Which of the three clearing regimes is to be preferred? Neither one is clearly superior as far as price variance is concerned; although the buffered system is slightly better than the liquid system. However, under the buffered system the specialist makes huge profits (cf. Table 8-6). This suggests that there is scope for reducing price variability under that regime. The buffered clearing system also has the advantage that a greater proportion of the investors' orders are executed. This result may be surprising. One would have thought that the liquid clearing system would have been superior at least as far as executing investors' orders. For this is the vaunted advantage of the liquid system : to enable an investor to liquidate or add to his portfolio instantly. The explanation lies in understanding what kind of liquidity the real world specialist systems provide. When a specialist sets a bid and asked price on the exchanges, he is committing himself to buy or sell only one round lot (100 shares) at those prices. If one seeks to purchase more than 100 shares at the bid price, he will not necessarily be able to do it. Really big blocks of 5,000 shares or more are handled mostly by prearrangement. Thus, if a mutual fund seeks to dispose of 20,000 shares of a stock, a broker will find a buyer for the block and the transaction would be carried out through the exchange at the predetermined price. If really big blocks were dumped

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

on the market without arrangement, the liquidity of the market would quickly dry up.

Investor Performance

Table 8-6 presents the performance record for each investor under the different clearing arrangements and disturbance sets.

By averaging over the three disturbance sets we can get each investor's mean performance with each market clearing system. If we take the five Fundamentalists, we get a 5 x 3 table showing how each Fundamentalist's performance turned out for each clearing arrangement. A two-factor analysis of variance calculation was performed for the five Fundamentalists. At the 1% level one can reject the null hypothesis that the categorical factor Koyck adjustment weight for the Fundamentalists has no effect on performance. The calculated F ratio was 8.4; while the critical F at the 1% level with 4 degrees of freedom in the numerator and 8 in the denominator is 7.01 . One can also reject the null hypothesis that the categorical factor clearing arrangement has no effect on performance. The calculated F was 28; whereas the critical F at the 1% level with 2 and 8 degrees of freedom is 8.65 .

When the two-factor analysis was done for the four Technicians, one was not able to reject the null hypothesis that the categorical factor Koyck adjustment weight for the Technician had no effect on performance. The

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

calculated F was ratio was 0.45; whereas the critical F at the 1% level with 3 and 6 degrees of freedom is 9.78 . One could reject, however, the null hypothesis that the categorical variable clearing arrangement had no effect on performance. The calculated F was 120, while the critical F at the 1% level with 2 and 6 degrees of freedom is 10.92 .

A Final Modification

The previous investigation of market performance under different clearing arrangements yielded ambiguous results. However, the comparison among market structures was not strictly valid. It was previously suggested that some of the buffered specialist's profits could be sacrificed to achieve smaller price variability. The reader will recall that the buffered specialist sets the transaction price in each period but is required to limit the period-to-period price change to a certain percentage. Another factor which made the results in Tables 8-5 and 8-6 less than strictly comparable was the greater initial endowment of the liquid specialist as compared to the buffered specialist.

To put the comparisons of the two systems on a comparable basis, one would like to endow the specialists with the same amount of wealth and would like their profit performances in the simulation runs to be approximately equal. Table 8-7 presents the results of a set of simu-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

lation runs where these conditions were met. The following points are relevant:

1. The limit on period-to-period price changes in the buffered system of Table 8-7 was 7%; whereas it was 10% in Table 8-5.

2. The two specialists had the same initial endowment for the simulation runs in Table 8-7. They started with 260 shares of stock and $51740.

3. For each disturbance set in Table.8-7 the profit performances of the two specialists are comparable.

4. The buffered specialist's profit performance in Table 8-7 is much lower in relation to his profit performance in the Table 8-5 runs.

5. As compared to Table 8-5, the variance of stock prices under the buffered specialist system is lower with disturbance sets A and C; and higher with disturbance set B.

6. For the liquid specialist system the variance in prices as compared to Table 8-5 has increased with disturbance sets A and B and is about unchanged with disturbance set C.

7. In Table 8-7 the buffered specialist system is superior to the liquid clearing system in regard to the variance of stock prices for every disturbance set.

8. The proportion of total market orders executed has decreased for the buffered clearing system of Table 8-7 as compared with that of Table 8-5.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 8-7 : Market Statistics with Different Clearing Arrangements

Buffered Clearing with Specialist(7% Limit on Price Changes)

Disturbance Set	Set A	Set B	Set C
Total market orders (volume)	73090	67851	71681
Proportion executed	.712	.641	.641
Trading volume	33676	29764	30035
Specialist trading/Trading volume	.455	.538	.469
Mean price of stock	165.2	168.0	161.0
Variance of stock prices	231.9	324.0	283.8
Corr. coef. for price changes	.009	-.064	.013
Percentage change in specialist's wealth	36.3	31.0	7.7

Liquid Clearing with Specialist (Initial Wealth of Specialist Equal to that of Buffered Specialist Above)

Disturbance Set	Set A	Set B	Set C
Total market orders (volume)	67779	66887	74480
Proportion executed	.427	.425	.376
Trading volume	28946	28431	27967
Specialist trading/Trading volume	1.0	1.0	1.0
Mean price of stock	174.7	168.7	170.3
Variance of stock prices	444.9	482.9	351.3
Corr. coef. for price changes	.073	-.022	.199
Percentage change in specialist's wealth	43.4	36.5	9.9

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

9. The proportion of total market orders executed has decreased for the liquid clearing system of Table 8-7 as compared with that of Table 8-5.

10. In Table 8-7 the buffered clearing system retains its superiority compared to the liquid clearing system in regard to the proportion of total market orders executed.

* * * * *

When the buffered specialist has changed his behavior so that period-to-period price changes are limited to 7% rather than 10%, we usually achieve a reduction in price variability. The buffered specialist's profits also declined spectacularly. In Table 8-5 the correlation coefficients for the price changes are negative, suggesting the buffered specialist was accentuating price fluctuations. In Table 8-7 the correlation coefficients are almost zero. It seems clear that the buffered specialist can make greater profits by increasing the variance of stock prices.

A similar conclusion emerges from a consideration of the liquid specialist system. When the initial endowment of the liquid specialist was reduced, the variance in stock prices increased. (Table 8-7 variances are greater than Table 8-5's). But the profit rate of the liquid specialist went up with greater price variance.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

In order to minimize price variability the specialists should have large capital resources at their disposal. But with low price variability the rate of return on the specialist's capital will be low. If the specialist is in a monopoly position and competition is not allowed, a less than optimum amount of capital will be devoted to the clearing system. This will mean greater price variability in stock prices but a higher rate of return for the specialist.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chapter 9 : Concluding Observations

If the securities markets are to enable individuals to diversify ownership of uncertain future claims efficiently, the individuals should have information concerning the parameters of the distribution of each asset's rate of return. Ideally, the rate of return on the financial asset should be related to the uncertain payouts of the tangible capital to which it represents an ownership claim. Excessive market price fluctuations which create market risk in addition to the real risk will cause a deadweight loss for the economy as a whole.

In an empirical study of a sample of securities, George W. Douglas regressed the price volatility of a stock on several independent variables including earnings volatility and dummy variables for whether the stock was traded on the New York, American stock exchange, or over-the-counter. He found that: "The greatest portion of price volatility is the constant term associated with the exchange on which it is traded."(7) New York Stock Exchange stocks had the smallest constant term. American Stock Exchange stocks had the highest term, with over-the-counter stocks in the middle. He also found that increasing the size of the standard deviation of $(\Delta E/E)$ would have a negligible impact on the standard deviation of $(\Delta P/P)$ where E is earnings and P is price.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

These results suggest that the particular market in which a security is traded will influence its price fluctuations. Among the peculiarities associated with each market are the investors in that market and the clearing structure of each market. In addition, there are characteristics intrinsic to each security which affect where it will be traded: the number of shareholders; the size, earnings, and financial stability of the company; and its ability to satisfy listing requirements of particular exchanges.

Investor Behavior

One aspect of stock price formation that has received attention in the dissertation is the role that different investor "types" may play. We have maintained a distinction between the Fundamentalists and the Technicians. This distinction is useful in evaluating the social function that each group serves. According to Hirshleifer (16): "I shall maintain that the distinction between speculation that is socially useful and speculation that is disfunctional is essentially perfectly correlated with the distinction in market lore between two types of speculative traders: the "intrinsic value" school and the 'technicians'." His view is that "intrinsic value" speculators bring prices closer to their equilibrium values; whereas technicians may cause excessive fluctuations which

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

give false signals to both investors and users of capital funds. If the market allows people who engage in socially disfunctional speculation to make profits, this would clearly be cause for worry. Hirshleifer feels that an "attempt should be made to explore the magnitudes of the two types of speculation under various institutional arrangements."(16)

The simulation runs provide evidence that technical speculation is not profitable for investors to engage in most of the time. The Fundamentalists perform a stabilizing function and tend to restore prices to equilibrium levels. However, there were certain instances where the Technicians overwhelmed the Fundamentalists and produced excessive price movements (cf. Run 3, Run 5, Run 38). In these cases the Fundamentalists did not have enough resources to reverse the price movement. In such cases the presence of a specialist will help to reverse the price movement since he is also using his resources to reverse the price movement.

The random walk hypothesis maintains that technical speculation will not be profitable. This should relieve some of Hirshleifer's apprehension about the dangers of technical speculation. Indeed, in most of the simulation runs technical speculation was unprofitable. One may argue that the simulation model is unrealistic because technicians would presumably learn from the past and not follow the same investment strategy. A defense of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

simulation model would be that it sought to capture a time span wherein investors engaged in no learning. It is a moot point how fast some investors learn, if ever. Since in the real world technical investors occasionally make profits as well as losses, it would be difficult to get them to realize that their "method" or investing was not responsible.

In the simulation model the investors of the same "type" differed in their Koyck adjustment weights. One aim of the dissertation was to test whether investors who adapt at different rates differ significantly in their performance. In Chapter 8 it was found that for the Fundamentalists the Koyck adjustment weight was a statistically significant factor. Those Fundamentalists with the lower weights tended to perform better. The Fundamentalists were reacting to random disturbances in the rate of return and those who gave low weight to each new random disturbance did better.

Market Structure

The effect of the institutional arrangements of the marketplace upon the price formation process has been a major focus of this dissertation. Hirshleifer (16) feels that a critical and analytical comparison of the U.S. securities exchanges with other exchanges is needed. He says: "The debate over the role of the specialist, for example, can surely benefit by an examination of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

methods whereby other exchanges are enabled to dispense with such a functionary."

In the Appendix to Chapter 4 we surveyed the various institutional arrangements used in stock exchanges around the world. One possible line of research would be to do a comparative empirical study of the various exchanges. One would gather data on the volume of transactions, the price volatility of stocks, the speed with which transactions are executed, etc. After overcoming formidable data problems for certain countries, the job of interpreting the results remains. Can one attribute the "thinness" of the Paris Bourse to the institutional set-up of the market clearing system? Or, should one attribute it to the lack of broad public participation in security markets, the lower standards of corporate disclosure, or the concentration of shares in inactive accounts rather than with day-to-day traders? If prices fluctuate more on Brazilian exchanges, is this a feature of the "call" system as it operates there or merely a reflection of the speculative character of the securities?

The approach chosen in the dissertation was to try to create ceteris paribus situations and through simulation to investigate the effect of different institutional arrangements. By constructing a simulation model we can better evaluate the way markets operate. For example, in the simulation runs dealing with market structure, we looked at the proportion of market orders cleared

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

by each system. First, we found the ex ante figure for total market orders placed. It represents the total amount of trading investors would like to engage in at the start of a market period. The ex post trading volume shows the actual amount of trading. The proportion executed thus reflects the degree to which the market accommodates the investors. As such, it is a highly useful statistic for evaluating the performance of the market under different market arrangements. Unfortunately, there is no way to obtain such a figure for the real world. The real world provides data only on ex post transactions. Many ex ante orders never arrive at the trading post. If a mutual fund wants to sell a large block of stock, it would be pointless to enter the order until some arrangement has been made concerning the disposition of the stock. This might take several days. During all this time there would be an ex ante market order which could not be accommodated. Similarly, an investor might decide to sell a stock on a certain day. However, if the price drops during the first half-hour of trading before he has time to enter his order, he may decide to defer selling his stock that day. Here again, an ex ante order does not enter the marketplace. One virtue of a formal model is that it can provide a record of all the orders, ex ante and ex post. For a proper evaluation of a market cannot rely on the ex post order series alone.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

On securities exchanges the specialists are often enjoined to "lean against the wind" in times of unbalanced markets. This directive seems to require the specialists to determine some normal level for a stock's price so they can feel which way the wind is blowing. It then requires them to judge how hard they should lean against the wind. Our initial attempt to structure the liquid specialist system shows how hard it is to find a set of rules that will stabilize the market yet provide the specialist with an acceptable level of profits. Through the construction of a formal model we are forced to specify precisely what the specialist is doing. Then, we can investigate the consequences of specific behavior patterns.

Transactions Costs

If we define transactions costs as the direct costs of exchanging ownership titles, these costs will fall into two categories:

1. brokerage commissions
2. ask-bid spreads

In the simulation model there were no brokerage fees. The presence of brokerage fees will cause two changes in investor behavior. First, it will decrease the frequency of transactions. Before consummating a transaction the investor will now need to anticipate a higher rate of return on his transaction so that he can

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

cover his commission costs. If commissions are proportionately larger on smaller transactions, we would also expect a tendency for the size of each transaction to increase. If, in the absence of commissions, an investor would hold 12 shares of stock in his portfolio, we may now find that he chooses to omit it rather than pay the high brokerage fees. Investors will be making less fine adjustments to their equilibrium position.

On the New York Stock Exchange there will usually be a spread between the bid price at which a stock may be sold and the asked price at which it may be bought. In an empirical study of a sample of stocks Demsetz (6) tried to explain the ask-bid spread. He used the following variables:

S = ask-bid spread measured in dollars

T = time-rate of transactions (number of separate recorded transactions per day)

P = price per share

N = number of shareholders measured in hundreds

M = number of markets on which security is traded.

His regression result was:

$$S = .38027 + .00807P - .11527 \ln T - .022906M$$

with an r^2 of .576 . The first two independent variables were statistically significant. The statistical analysis strongly indicates that the cost of exchanging a security declines as trading activity in that security increases. Demsetz then sought to explain the time-rate

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of transactions and found that $T = 9.4897 + .02263N$ with an r^2 of .52489 . With his variables Demsetz was able to explain about half the variation in S. This suggests that there are other variables to be considered. One factor might be the volatility of each stock which affects the size of the spread which specialists feel is necessary to protect themselves. Abstracting from risk, however, the ask-bid spread could also be a function of the aggressiveness with which each specialist unit enters the market -- either out of a sense of duty or a desire for greater profits. The degree of specialist participation would probably also be a significant variable for explaining the time-rate of transactions.

The SEC Report (36; part 2, p. 459) provides figures which show wide variation in the Specialist Transaction Participation Rate, which is the number of specialist transactions as a per cent of the number of market transactions. (cf. Table 9-1) Although there is a tendency for specialist participation to be greatest in the stocks with low volume, there are also many variations from this generalization. Ideally, one would like to correlate specialist participation with the bid-ask spread and with the profitability of a specialist's operation. However, the data for such a task is not available. It has been suggested that the New York Stock Exchange tape add a

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 9-1 : New York Stock Exchange Market Volume vs. Specialist Transaction Participation Rate

(Per Cent of stock days in each category of market volume falling into each range of specialist participation rate)

	Specialist Transaction Participation Rate				
Market Volume (Shares)	.01% to 16.00%	16.01% to 26.00%	26.01% to 37.00%	37.01% to 50.00%	50.01% and over
10,000 and over	42.5%	18.9%	18.9%	8.0%	1.7%
5,701 to 10,000	28.8	26.7	24.8	15.0	4.7
3,901 to 5,700	25.9	23.1	25.7	15.6	9.7
2,801 to 3,900	25.8	19.9	23.8	18.9	11.6
2,101 to 2,800	24.7	19.1	23.7	18.1	14.4
1,501 to 2,100	22.5	19.4	20.7	18.5	18.9
1,101 to 1,500	17.7	19.1	22.4	18.8	22.0
701 to 1,100	14.4	18.7	19.3	21.5	26.1
401 to 700	4.1	26.2	13.7	25.1	30.9
10 to 400	0.4	7.9	15.2	25.1	51.4

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

certain symbol after each transaction to denote whether the specialist participated in the transaction. Such a step would permit the type of analysis suggested above. (It would also be necessary to know whether the specialist took the entire block of shares in a transaction or a portion of it.) However, the NYSE has not taken this measure.

The simulation results indicate that it is not to the specialist's advantage to provide continuity between transactions. In the real world some competition is provided by traders who set "limit" orders. In the past there were competing specialists in some issues but now there is only one for each security. In the past the independent floor speculator competed with the specialist; but he too has disappeared. According to Hirshleifer (16): "The SEC has been hostile to the floor speculator, while the 'establishment' of the organized exchanges is closely tied to the specialist firms. It is not clear whether these political considerations suffice to explain the decline in importance of the floor speculator and the rise in importance of the specialist, or whether more purely economic forces tended in the same direction."

Criteria of Market Efficiency

There are several criteria by which the efficiency of a market may be judged. There are problems with drawing up any set of criteria and in this dissertation we have

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

touched upon only a few aspects of market efficiency. For example, we have neglected the question of the number of assets available to investors and how this would affect our social goal of providing a diversified variety of securities for individual needs and tastes. Hirshleifer calls this quality of the market "completeness". In underdeveloped countries there are probably too few companies listed on the local exchanges to provide adequately for the portfolio desires of individuals. But even in advanced countries some potentially desired securities may not be available. If someone wants to invest in the National Broadcasting Corporation, he would buy RCA stock; but also be investing in consumer electronics, computer manufacturing, a publishing operation, and Hertz Rent-A-Car. The Ford Motor company may not have issued a warrant which a particular investor may want (although the market offers a partial substitute with puts and calls).

We also want security markets to be "fair". This means putting everyone on an equal footing. It requires prompt and full disclosure by corporations of factors which might affect their business. It requires "insiders" to refrain from profiting from inside information. It may require brokerage firms to disclose to their customers whether they have a position in any stocks they are recommending. In the case of the specialist he is given

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the monopoly privilege of having information about the "limit" and "stop" orders in a stock. A concept of fairness might require this information to be publicly available. On the other hand, such disclosure may alter investors' behavior in such a manner as to induce undesirable speculation.

In the dissertation three market clearing arrangements were constructed. Each system can be ranked in comparison with the others for a specific criterion. For some criteria two systems might be tied for the second rank.

Table 9-2: Market Clearing Systems Ranked by Specific Criteria

	Pooled	Buffered with Specialist	Liquid with Specialist
Continuity	2	2	1
Depth (proportion of orders cleared)	3	1	2
Price variability	2	1	2
Accessibility	2	2	1
Capital Costs	1	2	2

The liquid specialist system would provide greater continuity between transactions. Presumably it would be open several hours a day and provide instant accessibility to investors during that time. The other two systems, requiring that orders be cumulated, would execute trades perhaps once or twice a day. Capital costs can

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

be considered from two aspects. From the standpoint of the individual investors the specialist is competing with them for trading profits. He requires remuneration for playing his role. From the standpoint of the economy resources may be deployed in a socially disfunctional use.

A social welfare function would be needed to weigh the costs and benefits of any particular system. We have seen that a buffered specialist system reduces price variability and increases the proportion of ex ante orders that are cleared. Would investors be willing to give up the instant accessibility of the liquid specialist system for these two benefits? There are also political considerations to keep in mind. Suppose the specialist function is provided by a public body, with any profits accruing to the government. Would such a system be acceptable to the Exchange, to brokers, to individual investors, to the SEC, to the Congress?

Perspectives on Future Research

In recent years the securities industry has undergone vast transformation. Among the new developments have been the predominant role of institutional investors, the operational problems of back-office staffs, the failure of several brokerage houses, and the rise of the "third" and "fourth" markets bypassing the exchange floor. The New York Stock Exchange is grappling with the problem

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of admitting large institutional investors to membership. A recent Wall Street Journal article (47) reported the establishment by the American Stock Exchange of a $300,000 experimental fund to provide quick loans to stock specialists in meeting extraordinary market conditions. The fund could be used to provide capital for large block transactions. The New York Stock Exchange has decided to boost the minimum capital requirement of its specialist units by 150%. Each unit would be required to be able to assume a minimum 5,000 share position in each of the common stocks in which it specializes(48). As it struggles with its problems, Wall Street may have to develop new institutions and structures. It may be necessary to merge the Big Board and the American, regional, and the over-the-counter market to form one vast "central marketplace" linked by a common communications network(51). Such changes may literally transform the exchanges. For example, the New York Stock Exchange is considering moving to a new site in lower Manhattan. One question it must ponder is the physical layout of the new building. Will a large trading floor where brokers scurry about and specialists man their posts be a necessary part of the exchange? Or would it be better to build a series of small offices? To decide this question one must consider what kind of trading conditions will materialize in the future, how the order clearing process will be structured, and the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

degree of automation that will be an element of the new process.

Economists have only recently begun to study the process whereby speculative prices are formed. The work of Smith, Fama, Osborne, and others have been steps in that direction. This dissertation has been an attempt to build a simulation model integrating some aspects of the problem. A good analogy for what the dissertation has tried to do may be to say that it attempted to map an n-dimensional surface. The n dimensions which comprise the model are quite large: the parameters of the structure, the number of investors, the functions describing their adaptive behavior, the characteristics of the market-clearing mechanism. In some places it has been possible to map the surface in detail, in others only outline the general contours. Hopefully, it will lead the way to better models for the analysis of pressing theoretical and practical problems.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Bibliography

1. Baumol, William J. The Stock Market and Economic Efficiency; 1965

2. Baumol, William J.; Heim, Peggy; Malkiel, Burton G.; and Quandt, Richard E. "Earnings Retention, New Capital, and the Growth of the Firm"; Review of Economics and Statistics; November 1970

3. Bellman, Richard Adaptive Control Processes; A Guided Tour; 1961

4. Clarkson, Geoffrey P. E. Portfolio Selection: A Simulation of Trust Investment; 1962

5. Cootner, Paul H. (editor) The Random Character of of Stock Market Prices; 1964

6. Demsetz, Harold "The Cost of Transacting"; Quarterly Journal of Economics; vol. 82, February 1968

7. Douglas, George W. "Risk in the Equity Markets: An Empirical Appraisal of Market Efficiency"; Yale Economic Essays; vol. 9, no.1, Spring 1969

8. Eiteman, David K. Stock Exchanges in Latin America; Michigan International Business Studies; number 7; 1966

9. Eiteman, David K. and Eiteman, Wilford J. Leading World Stock Exchanges: Trading Practices and Organization; Michigan International Business Studies; number 2; 1964

10. Fama, Eugene F. "Risk, Return, and Equilibrium"; Report 6831, Center for Mathematical Studies in Business and Economics, University of Chicago, June 28, 1968.

11. Fama, Eugene F. "Efficient Capital Markets: A Review of Theory and Empirical Work"; Journal of Finance; May 1970

12. Fisher, Lawrence and Lorie, James H. "Rates of Return on Investments in Common Stock: The Year-by-Year Record, 1926-65"; Journal of Business; vol. 40, no. 3, July 1968

13. Fortune. Personal Investing: "The Case against the Random Walk"; July 1, 1966; pg. 159-60.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

14. Fundscope. "1961-68 Performance Results"; vol. 12, no. 3, March 1969

15. Gordon, Myron J. The Investment, Financing, and Valuation of the Corporation; 1962

16. Hirshleifer, Jack "Reflections on the Role and Functioning of the Organized Exchanges"; unpublished paper

17. Hogg, Robert V. and Craig, Allen T. Introduction to Mathematical Statistics; 1965

18. Jensen, Michael C. "The Performance of Mutual Funds in the Period 1945-64"; Journal of Finance; May 1968

19. Jensen, Michael C. "Random Walks: Reality or Myth?" Financial Analyst's Journal; November-December 1967

20. Johnston, J. Econometric Methods; 1963

21. Lerner, Eugene M. and Carleton, Willard T. "The Integration of Capital Budgeting and Stock Valuation"; American Economic Review; December 1964

22. Levy, Robert A. "Random Walks: Reality or Myth"; Financial Analyst's Journal; November-December 1967

23. Levy, Robert A. "Random Walks: Reality or Myth - Reply"; Financial Analyst's Journal; January-February 1968

24. Levy, Robert A. "Relative Strength as a Criterion for Investment Performance"; Journal of Finance; December 1967

25. Little, I. M. D. "Higgledy Piggledy Growth"; Bulletin of the Oxford Institute of Statistics; November 1962

26. Markowitz, Harry M. Portfolio Selection; 1959

27. Minsky, Hyman P. "Financial Crisis, Financial Systems, and the Performance of the Economy" in Private Capital Markets; 1964

28. Modigliani, Franco and Miller, Merton "The Cost of Capital, Corporation Finance, and the Theory of Investment"; American Economic Review; June 1958

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

29. Mossin, Jan "Optimal Multiperiod Portfolio Policies"; Journal of Business; April 1968

30. Murphy, Roy E. Adaptive Processes in Economic Systems; 1965

31. Osborne, M.F.M. "The Dynamics of Stock Trading"; Econometrica; January 1965

32. Pratt, John W. "Risk aversion in the small and in the large"; Econometrica; Jan.-April 1964

33. Raiffa, Howard and Schlaifer, Robert Applied Statistical Decision Theory; 1961

34. Rinfret, Pierre A. "Investment Managers Are Worth Their Keep"; Financial Analyst's Journal; March-April 1968

35. Ryan, J. M. and Garder, A. O. "The Measurement of Dynamic Risk"; Southern Economic Journal; January 1965

36. Securities and Exchange Commission Report of the Special Study of the Securities Markets of the Securities and Exchange Commission (88th Congress, 1st session, House Document 95, 1963)

37. Sharpe, William F. "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk"; Journal of Finance; September 1964

38. Sharpe, William F. "Mutual Fund Performance"; Journal of Business; January 1966, Part II

39. Shubik, Martin "A Note on a Simulated Stock Market" Cowles Foundation Discussion Paper, no. 249, April 10, 1968

40. Smith, Vernon Lomax "Effect of Market Organization on Competitive Equilibrium"; Quarterly Journal of Economics; May 1964

41. Smith, Vernon Lomax "An Experimental Study of Competitive Market Behavior"; Journal of Political Economy; April 1962

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

42. Spray, David E. (editor) The Principal Stock Exchanges of the World -- Their Operation, Structure and Development; 1964

43. Stigler, George J. "Public Regulation of the Securities Markets"; Journal of Business; April 1964

44. Tobin, James "Economic Growth as an Objective of Government Policy"; American Economic Review; December 1964

45. Tobin, James National Wealth and Individual Wealth; manuscript; May 25, 1959

46. Uemura, Shigeru Japan Stock Exchange Manual; 1st edition; Tokyo, The Daiwa Securities Co., 1963

47. Wall Street Journal "American Board Plans Lending Experiment to Aid Specialists in Trading Crunches"; February 3, 1971; page 2

48. Wall Street Journal "Big Board to Boost the Minimum Capital of its Specialists by 150% as of June 1"; February 24, 1971

49. Wall Street Journal "SEC Seeks Crackdown on Institutions Aiding Corporate Take-Overs"; March 8, 1971

50. Wall Street Journal "SEC Finds No Close Link of Institutions to Price Swings; Doubts Need for Curbs"; March 11, 1971

51. Wall Street Journal "Martin Exchange Study Is Likely to Recommend a Merger of Markets"; April 30, 1971

52. Wallich, Henry C. "What Does the Random Walk Hypothesis Mean to Security Analyst's?"; Financial Analyst's Journal; March-April 1968

53. Ying, Charles C. "Stock Market Prices and Volumes of Sales"; Econometrica; July 1966

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.