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The impact of bid-ask spreads on return computations and empirical anomalies.

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THE IMPACT OF BID-ASK SPREADS
ON RETURN COMPUTATIONS AND EMPIRICAL ANOMALIES

A Dissertation Presented

By

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ABSTRACT

THE IMPACT OF BID-ASK SPREADS

ON RETURN COMPUTATIONS AND EMPIRICAL ANOMALIES

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A substantial body of literature on security market anomalies has emerged since the general acceptance of the Efficient Markets Hypothesis. Two major areas are observed in this literature. The first examines information effects on security price behavior. This literature analyzes the price adjustment lags in response to new information. The second investigates empirical anomalies; size effects, weekend effects, and January effects. Studies in both areas have largely depended on an analysis of returns computed from closing prices.

This study examines the impact of alternative specifications of the return generating process in testing previous findings of empirical anomalies. Specifically, the study assesses the usefulness of returns generated in a manner consistent with the use of "market" and "limit" orders by public traders. Accordingly, returns measured ask-to-bid and bid-to-ask are utilized to test the persistence of the empirical anomalies. The empirical results support the hypothesis that the misspecification of the return generating process in previous market studies is in part the cause of anomalous findings of market inefficiencies.

This study also examines whether more efficient estimates of relative risk (beta) can be estimated when returns are measured using alternative price structures (i.e., means of closing bid-ask prices) for market index construction. These alternative return models are expected to produce more efficient estimates of beta. The empirical results demonstrate that small increases in beta estimation efficiency can be achieved when the mean of the closing bid-ask price quotes are used in the place of closing prices.

Empirical evidence is presented which sheds further light on the nature of the negative serial correlations observed in discrete price series. The evidence supports the hypothesis that market behavior is substantially predictable in the very short term. The ability to forecast the direction of the next day's return is, however, of negligible economic value due to costs and institutional restraints.

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CHAPTER 1

INTRODUCTION

1.1 The Valuation Problem

The central problem in finance is the valuation of financial assets. The inputs into the analytical framework for valuation are the size of anticipated returns, the dates those returns are to be received, and the risk undertaken to obtain those returns. The last input, risk, is the most difficult variable to measure and incorporate into the valuation process. The simplest definition of risk is the variance of the income stream of a financial asset over time. The greater the variation in anticipated income streams, the greater the risk. The level of risk is critically important as it helps to fix the level of the required or expected rate of return.

A significant advance in asset valuation was the development of the Capital Asset Pricing Model (CAPM). The CAPM decomposes risk into two categories; systematic risk and nonsystematic risk. Systematic risk is that portion of total security return fluctuations (including dividends) resulting from the co-movement of individual security prices with the market. Nonsystematic risk is the residual after subtracting the systematic portion. It is largely that portion of total security return fluctuations (including dividends) resulting from news about a particular issuer. Security prices move with the broader market in response to changes in important economic forces (macro economic variables) or change in response to new information regarding the company's prospects (micro economic variables). The effects of nonsystematic risk can be minimized by combining different securities into a portfolio. Thus, within the framework of the CAPM, only systematic sources of risk are priced.

The CAPM assumes that investors are risk averse. They prefer less risk to more for a given level of return. The normative imperatives of the CAPM suggests that investors will hold a mean-variance efficient (well diversified) portfolio (the market portfolio) in combination with a risk free asset. The proportions of the market portfolio and risk free asset are determined by the risk preferences of each investor. An investor unwilling to undertake risk will hold a larger proportion of his (her) wealth in the risk free asset. The CAPM also states that the trade-off between (beta) risk and return is linear.

1.2 Market Efficiency

An important association in the CAPM framework is the relationship between information and prices. In efficient markets, observed prices accurately reflect all publicly available and historical information. This is the theoretical content of the Efficient Markets Hypothesis (EMH). The CAPM explicitly assumes that markets are efficient; observed prices are true prices. At the center of efficient market dynamics is the question of whether observed prices accurately reflect all the information necessary to allocate capital efficiently among competing uses. Thus tests are performed to ascertain if observed prices incorporate all information contained in past prices (weak form efficiency), if all publicly available information is incorporated in observed prices (semi-strong form efficiency), and if observed prices accurately anticipate inside information (strong form efficiency).

1.2.1 Weak Form Efficiency

Early research in security markets revealed the presence of serial dependencies in returns generated using daily closing prices, and regularities in the variation of intraday prices. The independence of successive returns is at the heart of efficient markets theory. Returns are assumed to follow a random walk. The random walk model, a restrictive form of the EMH, assumes that successive returns are independently and identically distributed over time. The existence of positive or negative correlations implied the possibility of potentially exploitable patterns in sequential returns; the correlations could be used to earn (abnormal) risk-adjusted profits. Alexander (1961), and Fama and Blume (1966) examined the presence and magnitude of serial price dependencies and concluded that the small magnitudes of the serial dependencies precluded opportunities for earning abnormal profits after transaction costs. The transaction costs specified in these studies consisted of brokerage fees and did not specifically include liquidity costs.

1.2.2 Semi-Strong Form Efficiency

The incorporation of new public information in security prices is at the heart of the semi-strong form of the EMH. Testing of the semi-strong form EMH is facilitated with the use of event studies. These studies examine the speed with which security prices adjust to new information. In an efficient market, prices rapidly adjust to new information; no opportunities should exist for earning abnormal profits by acting on new information. The market model and returns generated from closing prices are utilized to test for semi-strong form market efficiency. Early security market research generally supported the semi-strong form of the EMH (Cf. Ball and Brown [1968], Fama, Fisher, Jensen, and Roll [1969]). More recent studies, however, have identified abnormal profit opportunities existing beyond an information event when the information is unexpected. Ball (1978) reviewed fifteen separate event studies reporting excess returns persisting beyond the unexpected information event. The inconsistency of semi-strong form market efficiency research results have generally been attributed to misspecifications of the two parameter model used to describe equilibrium in the stock market.

1.2.3 Strong Form Efficiency

The EMH holds that security prices fully reflect not only public information but also properly anticipate inside information. Most studies examine the ability of professional portfolio managers to outperform the market averages. The most frequent research result is that professionals are unable to outperform the market averages on a consistent basis. The important exceptions to these general studies are the profits obtained by corporate insiders and stock exchange specialists. Studies by Jaffe (1974), Finnerty (1976), and Nunn, Madden, and Gambola (1983) indicate that insiders are able to outperform the market averages on a consistent basis.

1.3 Market Microstructure and Trading Behavior

In perfect and efficient markets, each asset trades at one price at a given point in time. Also, the price at which a trade is consummated is assumed to be equal to the true or intrinsic value of the asset. Efficient markets are also liquid: Financial assets may be readily bought and sold at their intrinsic values. An implicit assumption of the asset pricing models pertains to the nature of liquidity. Liquidity obtains when buyers are ready to transact with sellers at a price equal to the intrinsic value of the asset being traded; if a seller cannot find a buyer, the market is not (perfectly) liquid. The asset pricing models generally assume that buy and sell orders for the same security occur simultaneously through time; both orders reach the point of transaction at the same time (Cf. Garman [1976]). In the language of real markets, orders are "crossed." This should not be interpreted to mean that all orders are crossed, but that the average transaction price is equivalent to the intrinsic value of the security. If markets are illiquid, transaction values might have to differ substantially from intrinsic values to facilitate desired trades. Illiquidity implies an undesirable cost. The existence of liquidity can only be sustained with synchronous (continuous) trading and a sufficient number of market participants.

Real security markets are characterized by nonsynchronous buying and selling; matching buy and sell orders do not arrive at the trading point at the same time. The nonsynchronous nature of trading requires the establishment of liquidity services in order to provide the essence of a continuous market (Cf. Demsetz [1968], Smidt [1971]). Liquidity services are especially important for traders in stocks characterized by low daily volumes of shares traded. Thus a buyer (seller) may not always have a seller (buyer) to balance the transaction. Accordingly, institutional (i.e., stock exchange) arrangements are made for the provision of liquidity services. Liquidity (or immediacy) services are provided by specialists on the floor of the NYSE or by market maker-dealers in the over-the-counter (OTC) market. The cost of liquidity services are the mark-ups or mark-downs buyers or sellers incur when trades are consummated. In such trading, the specialist represents the other half of the trade. The costs of immediacy services provided by the specialist are important because they affect the cost of capital for firms in accordance with the level of prices and daily trading volume. Moreover, the prices at which immediacy transactions occur may not be equilibrium prices.

The prices utilized to generate returns in the asset pricing models are usually the last trade (closing) prices of a security. The implicit assumption of this particular return generating process is that the closing price is the price which would be obtained in buying or selling the asset at that particular point in time. The formal structure of the CAPM does not directly address the operating dynamics of the market at the micro-structure level. The asset pricing theory is cast in terms of perfect capital markets; no transaction costs and taxes, buyers and sellers are price takers in a competitive market, and all economic players have equal and costless access to information. General treatment of these assumptions suggest that they may be relaxed without impairing the [theoretical] results. Real markets are imperfect. Transactions costs and taxes are nonzero. All players do not have equal and costless access to price relevant information. Also, the general equilibrium CAPM has nothing to say about the possibility of trading opportunities. Finally, and most importantly, buyers and sellers are not atomistic price takers exchanging assets at intrinsic values. The nonsynchronous nature of trading in real markets impose additional burdens on public traders; they frequently transact with the market maker/ specialist at prices favorable to the latter (Cf., Bagehot [1971]).

The empirical examination the CAPM treats the closing price as an equivalent of intrinsic value. Also, this closing price is implicitly assumed to be the (market clearing) price which would prevail in trading activity. Thus any deviations of actual (trading) prices from the intrinsic price structure would necessarily result in measurement errors or biases in computed returns. The probability is high that returns computed from observed (closing) prices are inconsistent with the assumptions of the CAPM. We note, however, that the CAPM is a general equilibrium model which is not affected by the type of return utilized; thus any reasonably constructed return could be used to test the two-parameter asset price model.

An important part of the assumption content of the asset pricing theory holds that equilibrium prices are (by definition) market clearing prices. Observed transaction prices may be viewed as being market clearing prices but such prices are not necessarily equilibrium prices. Thus the possibility exists that some of the observed closing prices are inconsistent with intrinsic values. The implication of this potential inconsistency is that it casts doubt on the suitability of returns computed from observed closing prices when those returns are used in the [equilibrium] asset pricing model. If returns computed from closing prices are not equilibrium returns, then the asset pricing models may not be correctly pricing real or financial assets. The incorrect pricing of assets would result in the misallocation of capital.

1.4 Market Anomalies

A considerable number of security market researchers have attempted to explain the behavior of its participants by studying the behavior of prices in the context of an asset pricing theory. The theoretical components of that framework are efficient markets theory and the capital asset pricing model. Efficient market theory suggests that observed prices are equal to intrinsic values. This result obtains from the informational efficiency said to characterize the market for investment assets. The capital asset pricing model outlines the method for utilizing observed returns together with variance and covariance structures to price securities.

A substantial body of literature on security market anomalies has evolved since the general acceptance of the Efficient Markets Hypothesis (EMH). This literature may be dichotomized into two distinct areas. The first examines information effects on security price behavior (event studies). This literature analyzes price adjustment lags in response to new information. The second examines a different set of empirical anomalies; size effects, weekend effects, and January or turn-of-the-year effects. These empirical anomalies demonstrate price and return behavior inconsistent with that suggested by efficient markets theory and the capital asset pricing model. Weekend and January effects reflect systematic regularities in stock returns inconsistent with the EMH. Size effects result in returns incompatible with those predicted by the capital asset pricing model.

Most of these studies utilized returns computed from closing prices. The possibility that returns computed from closing prices differ significantly from equilibrium returns may underlie findings of market anomalies when [joint] tests are made of market efficiency and the specification of the CAPM.

1.5 Research Objectives

Two observations may be made at this point. First, the case against the EMH as a realistic theory explaining the behavior of prices appears to be substantial. One possible explanation is that the capital asset pricing model is inadequate or misspecified. Another possibility is that the return generating process is misspecified yielding incorrect estimates of risk and return. Of the three forms of the EMH, only the weak form stands relatively unchallenged. The semi-strong form has been repeatedly challenged in the event study literature, although without a completely unqualified result. Research on abnormal returns accruing to traders with inside information is widely regarded as negating the strong form EMH.

The second observation concerns the specification of the return generating process. Virtually all empirical security market research has been based upon returns computed from closing prices. While readily available on the major data tapes, such returns may not accurately reflect what a real world trader would earn. As the last reported transaction, the "close" may take place at the closing bid (highest unexercised offer to buy), closing ask (lowest unexercised offer to sell) or somewhere within or even outside the end-of-day bid-ask range. Indeed, stocks can "close" (last trade) at any time during the day. Thus closing prices may bear relatively little relation to the market situation at the end of the day. Also, closing prices may not adequately reflect prices obtainable by traders. Results reported by Branch and Echevarria (1986) suggest a significant bias is introduced into returns when those returns are generated using closing prices. These biases are the result of a misspecification of the return generating process.

The general objectives of the current study are:

1. to determine the effects of biases introduced by the use of closing prices to compute returns.
2. to examine the effects of alternative specifications of the return generating process on market anomalies.
3. to examine the effects of alternative specifications of the return generating process on measures of risk and return.

The alternative specifications of the return generating process are useful in determining the effects of specialist/market maker spreads on obtainable returns and the implicit effects on the cost of capital.

1.6 The Theoretical Model

In economic theory, the equilibrium price is the price which equilibrates the supply of commodities with the demand for those commodities. In the basic Walrasian model, equilibrium is assumed to be attained through a process of tatonnement with recontracting. No trades are consummated until buyers and sellers agree on the equilibrium set of prices for commodities to be exchanged. In theory, equilibrium prices and quantities for all commodities are simultaneously determined. Moreover, in equilibrium, neither excess demand nor excess commodities exist. The incidence of production and consumption are identical in time. This theoretical structure has been extended to the market for financial assets (claims on future sums of money). The essence of the theory is the suggestion that markets move from one point of equilibrium to the next without intervening activity.

In general equilibrium, the equilibrium price is also termed the market clearing price. The critical assumption in this general scheme is the instantaneous determination of equilibrium prices and quantities. If we vacate or relax this price adjustment assumption, then we cannot maintain that market clearing prices are necessarily equilibrium prices. Transaction prices can be deemed to be transitory market clearing prices as markets move from one equilibrium point to the next. All asset pricing theories assume that market clearing prices are equilibrium prices. This relationship results from instantaneous price adjustments in response to new information in a perfect and efficient market. Moreover, these relationships form the theoretical content of the efficient markets hypothesis.

The realities in the securities marketplace require alternative arrangements when time preferences do not coincide. This adjustment takes the form of third parties who stand ready to buy into their inventories the output of producers and to sell from those inventories to consumers. The implicit fees charged by these third parties (mark-ups or mark-downs) are the compensation for the risk undertaken in providing all economic players flexibility from having to coincide perfectly their production and consumption decisions. As a consequence, the prices received or paid are affected by the magnitude of the fees charged. The magnitudes of the fees are in turn determined by the perceived levels of risk.

Observed security prices (closing prices) are explicitly assumed to be market clearing prices. Also, the structure of the [security] valuation theories assume that these values are equilibrium prices readily obtainable in markets which are continuously trading or are characterized by synchronous trading. When markets do not trade on a continuous or synchronous basis, arrangements are made similar to those existing in commodity markets. Third parties, specialists, stand ready to transact, for a fee, with traders desiring immediate execution of their orders. The result is a change in the prices received or paid. These prices are market clearing prices in the context of individual trades, but these prices are not necessarily equilibrium prices. Also, the returns computed from these prices are not necessarily the equilibrium returns envisioned in the asset pricing theory. The fees charged by the specialists affect the level of transaction prices and the returns realized or expected. Further, these fees affect the realized rates of return and, by implication, the cost of capital. Any valuation model would be misspecified if it did not include a provision for the effects of the fees charged by providers of liquidity.

The essence of the models to be defined in the current study stem from the assumption that markets do not equilibrate instantaneously. Instead, market transactions are viewed as the process by which markets seek to establish equilibrium values under general conditions of uncertainty. The levels of uncertainty are not only affected by investor perceptions about the true state of nature, but also by the specialist. In this sense, market activity appears as a series of transactions at prices simply viewed as transitory market clearing prices. This view is supported by the observation that many transactions are completed at prices different from the theoretically defined equilibrium price.

1.7 Methodology and Sample

One method for investigating the nature of market efficiency and the asset pricing models is to examine the implications of alternative assumptions about the form of the return generating process. The form of the existing return generating models are constructed in a normative sense; they assume informational efficiency in a perfect market, general equilibrium in the commodity markets and an extension of that equilibrium to the capital markets. Consequently, closing prices are assumed to be identical with equilibrium prices. Also, returns computed from these closing prices are assumed to be equilibrium returns. Alternative specifications of the return generating process would be driven by a positive view of market behavior; an imperfect market which strives to be informationally efficient. The set of prices used will reflect the prices most likely to be obtained by a public trader. Accordingly, we will not assume that observed transaction prices are equilibrium prices. This inquiry will treat observed prices as transitory market clearing prices. The imperfections of the market for financial assets are held to be captured in the bid and ask spreads which reflect the discontinuous nature of trading activity.

The general focus of this research is the examination of the effects on computed returns when those returns are measured for positions that are bought and sold with market orders. These are the returns most likely to be earned by public traders. For comparative purposes, this analysis will also examine the results of using prices from a limit order strategy to compute returns. Both sets of returns will be compared to returns measured in the traditional manner. The degree to which biases are induced in returns computed using closing prices will be measured as the difference between the returns measured close-to-close and returns measured ask-to-bid (assuming a market order to buy and sell). Close-to-close returns will also be compared with returns measured bid-to-ask (assuming execution of a limit order).

The current study will examine the effects of alternative return generating models on previous findings of empirical anomalies. We will determine if mis-specifications of the return generating process are the cause of the size effects, January effects, and weekend effects. The inquiry will utilize and compare all three methods examined by Roll (1983) for computing mean returns; buy and hold, rebalanced, and arithmetic average portfolio returns using close-to-close, ask-to-bid, and bid-to-ask price information. This comparison will provide additional insight into the effects of measurement bias introduced by the use of close-to-close returns in size effect studies.

One issue related to market efficiency studies is the autocovariance properties of observed prices. Accordingly, we utilize the data sample to examine next day behavior of prices and returns when today's closing price distribution is known. Specifically, we are interested in the relation between today's close and tomorrow's return. This work builds on earlier studies by Neiderhofer and Osborne (1966) reporting the presence of serial dependencies in intraday price movements. The presence of autocorrelation in sequential price series is a statistically troublesome phenomena. Herein we examine the phenomena to determine if any additional characteristics of the regularities exist beyond those previously reported.

The availability of a sample containing the closing bid and ask price quotes in addition to closing prices will permit comparisons of the DJIA constructed in the usual manner and one constructed with closing ask quotes, bid quotes, or the average of the two. These indexes will then be compared to the traditional index and the differences will be noted. The reconstructed indexes will then be used as a proxy for the market portfolio and betas will be estimated for various portfolios and individual securities. The primary purpose of these estimates will be to determine whether more efficient estimates of relative volatility are possible using indexes constructed under alternative methods. This inquiry does not reexamine the market efficiency issue. What is germane in this particular study is how alternative measures of price might influence the construction of an index (ie., the DJIA). Also, if alternative constructs are possible, they may allow for better tests of market efficiency regarding efficient betas or a stronger relationship between risk and return.

The current investigation utilizes two data samples. The first sample includes 42 days of closing, bid, and ask price quotes for 1134 NYSE issues for initial testing of the research hypotheses. This sample is referred to as the "test sample one." A second sample includes 43 days of closing, bid, and ask price quotes for 1205 NYSE issues. This second sample is referred to as the "test sample two." The two samples cover a bear (December 1981 - January 1982) and a bull (December 1982 - January 1983) move in the market. The two samples may help to make somewhat stronger generalizations than would a single two month sample.

The two samples combined, however, are still smaller than most samples typically used in market studies. Two arguments can be made to support the results of this study. First, the current samples are the largest ever used in examining market microstructure behavior and trading effects. Second, the strength of statistical tests suggests that an extremely large sample is not necessary to ascertain the general characteristics of the population. This is particularly true if the behavioral characteristics of two sub-samples can be demonstrated to be similar. The strength of this study derives at least in part from that demonstration.

1.8 Research Implications

This investigation is expected to provide several useful insights into the behavior of security markets and the problems engendered by attempting to demonstrate normative abstractions too far removed from empirical realities. First, this investigation should provide useful data on the extent of biases induced in returns when those returns are computed solely with the use of closing prices. Second, this study will provide an alternative analysis of the nature of empirical anomalies. In particular, this study will demonstrate how results vary when alternative specifications of the return generating process are utilized to define price structures and measure returns. The use of alternative price structures result from the imperfections of the market.

This investigation will also provide additional information regarding the nature of serial price correlation in observed prices. The degree to which regularities exist will bring into question the putative randomness of security prices. The nature of the results will permit certain characterizations to be reformulated about the efficiency by which capital is allocated and its costs determined. Finally, the most important implication of this study concerns the manner in which security market research has been conducted. This implication is particularly germane in the area of market efficiency and asset pricing.

This study will offer results which are likely to be critical of efficient market theory. The intent of this research is to emphasize differences in the results achieved in this study and those of prior studies. We seek to increase our understanding of the limitations to what we think we know about security market behavior. Accordingly, the results reported herein are seen as important contributions to our knowledge of the operations of security markets.

A significant amount of work still remains to be done in reviewing tests of the efficient markets hypothesis as a unified theory explaining the behavior of security prices. The nonrandom behavior of security prices and the potential for biases in returns measured from closing prices suggest that alternatives be considered. While the articulation a of new asset pricing paradigm is not suggested, the use of alternative return measures to confirm or deny the strength of market efficiency theory and the asset pricing models is suggested. Returns should be generated in a manner which most closely reflects the actual operation of the market. Thus realistic testing of these anomalies should assume the use of market orders (the only type that assures a trade).

1.9 Outline of the Study

The remainder of this study is organized as follows: Chapter II reviews the relevant body of literature relating to spreads, specialist behavior, and empirical anomalies. Chapter III presents the principal hypotheses to be examined and the form of the test procedures. Chapter IV describes the research methodology and the sample data set. Chapter V contains a detail description of the characteristics of the data set and the initial set of empirical results. Chapter VI contains the empirical results of the market anomaly tests. Conclusions and implications of the study are contained in chapter VII.

CHAPTER 2

LITERATURE REVIEW

2.1 Transaction Costs on the NYSE

In imperfect markets, securities may trade at more than one price. As described in chapter I, stocks may trade at the bid, ask, or inside the bid-ask spread. Bid and ask prices are necessary because of the nonsynchronous nature of trading activity in real markets. Bid-ask spreads are transaction costs incurred when services are provided which free transactors from the requirement for a matching order on the other side of the transaction: One essence of perfect markets is costless, synchronous trading. Given the structural arrangements of imperfect security markets, security transactions are subject to two sources of transaction costs; brokerage fees and bid-ask spreads. Brokerage fees were previously set by general agreement among member firms of the New York Stock Exchange (NYSE). Since May 1, 1975 fees have been largely set by competitive forces. These fees are based on share price and number of shares traded; the higher the price of the stock and the greater the number if shares traded, the greater the brokerage fee. The relative (%) cost of transacting, however, per dollar exchanged is lower for higher priced stocks and larger size trades.

The relevant characteristic of brokerage fees is that they do not consider the riskiness of any particular security or its level of trading activity. Thus securities appear "equal" when brokerage fees are considered; two securities trading at the same price would incur the same brokerage fee from the same broker. This "equality" does not extend to the structure of bid-ask spreads. Bid-ask spreads (the difference between the highest unexercised offer to buy and the lowest unexercised offer to sell) are observed to be substantially less homogeneous than brokerage fees due to the sensitivity of bid-ask spreads to price levels, trading volume, and specialist perceived levels of risk. This study does not address the impact of brokerage fees on realized returns. The primary focus of this research is the effects of bid-ask spreads. Accordingly, this study will assume a uniform schedule of brokerage fees for a single round lot (100 shares) at intervals similar to the price stratified deciles utilized in this study. However, when spreads are analyzed with a price stratified sample, certain general relationships between price and bid-ask spreads are apparent. Figure 2.1 (p. 21) demonstrates the nature of these relationships for test sample one (TS1).

Stocks in TS1 (1134 issues covering 42 days of trading) are classified by price into deciles and decile averages calculated for share price, percentage bid-ask spread and dollar spread. The logarithm (log) of the average percentage spread (left-side y-axis) is plotted against the log of the average share price per decile (x-axis). The log of the average dollar spread (right-side y-axis) is also plotted against the average share price. The graph clearly shows that the percentage spread declines as stock prices get larger. Moreover, the relationship appears to be a log-linear function. The somewhat obvious exception is the percentage spread for the lowest price decile. As demonstrated in figure 2.1, the relative spread for the lowest price decile departs from the strict linearity of the other deciles. This departure may be related to previously reported findings of abnormal returns accruing to low price stocks, the stocks

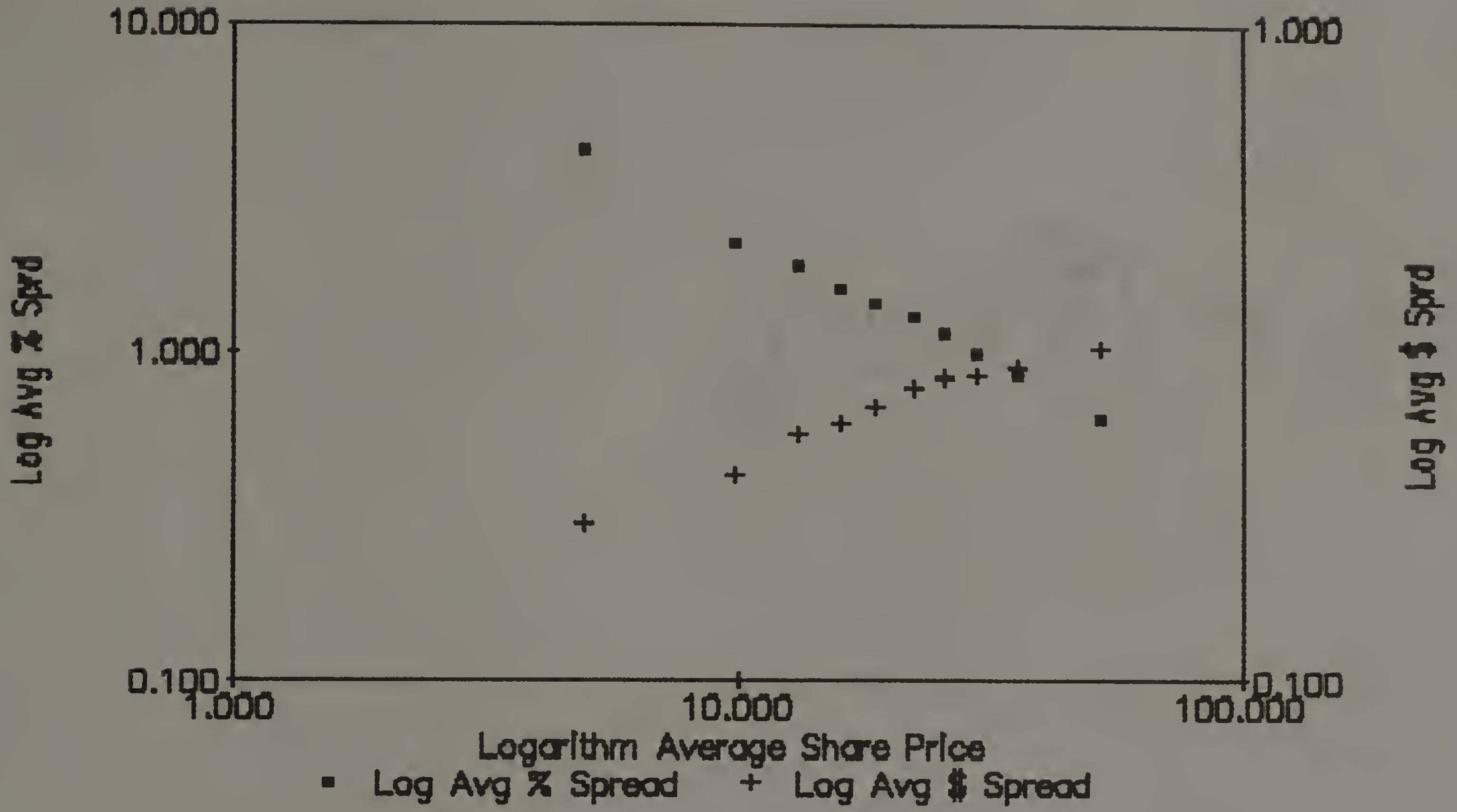

Figure 2.1 Bid-Ask Spread versus Average Share Price by Decile. Results are graphed for test sample one.

of small firms, and firms with low market values of equity. Figure 2.1 also shows that the proportional increases in dollar spreads are also log-linear in terms of increases in price per share.

Demsetz (1968) observed that;

> ...A security's price must also affect the spread quoted for quick exchange. Spread per share will tend to increase in proportion to an increase in the price per share so as to equalize the cost of transacting per dollar exchanged. Otherwise, those who submit limit orders will find it profitable to narrow spreads on those securities for which dollar spread per dollar exchanged is larger. (p. 45)

Demsetz also suggested that the lack of strict proportionality in brokerage commissions could result in the attenuation of the "strict proportionality" (p. 45) in specialist imposed transaction costs. Furthermore, the bid-ask spread for any individual security is sensitive to the volume of trading activity in that security and this sensitivity affects realized returns in a manner distinctly different from brokerage fees.

In as much as securities tend to trade noncontinuously, institutional arrangements are required in order to provide liquidity or immediacy services for traders demanding immediate execution of their orders. Demsetz (1968) described the bid-ask spread as "...the markup that is paid for predictable immediacy of exchange in organized markets." (p. 36) The specialist function on the floor of the NYSE provides liquidity services by imposing a dual price structure. The specialist stands ready to buy (sell) at the quoted bid (ask) price from (to) those traders desiring immediate execution of their sell (buy) orders. If markets are efficient, the bid-ask spread should straddle the true price. In effect, the trader who demands an immediate execution pays a "penalty" equal to one-half of the spread. This penalty increases the cost basis on a buy and reduces the proceeds on a sale. A "round trip" incurs the full amount of the spread. An important characteristic of the bid-ask spread is that it varies according to the several aspects of the market for each security. Hence stocks trading at the same price but with different daily volumes or price volatilities are subject to different spreads.

The cost of [equity] capital for a firm reflects the rate of return required by investors who buy and hold the firm's [equity] securities. The total rate of return experienced by investors is affected by the level of transaction costs. Demsetz (1968) suggested that a portion of the difference in "...borrowing costs between large and small firms can be attributed to differences in the cost of transacting rather than to imperfections in the capital market" (p. 34). The importance of Demsetz' study resides in its suggestion of a relationship between transaction costs and the cost of capital.

The buying and selling of a firm's securities does not by itself change the cost of the firm's capital. This change is brought about by changes in the rates of returns investors desire to achieve. The dynamics of this suggestion are fairly simple. Investors will attempt to pass on to other investors any costs incurred which reduce achievable rates of return. The effective result is an increase in the gross required rate of return achieved by adjusting the price at which they wish to sell or buy. This grossing up of the investors required rate of return results in an effective increase in the cost of capital for the firm. The amount by which investors gross up the required rate of return is directly a function of the magnitude of the transaction costs incurred at the brokerage level and on the floor of the stock exchange. Since brokerage fees are essentially fixed by competitive forces, bid-ask spreads imposed by the market maker/ specialist function are important determinants of the price adjustments made by investors. This suggests that the return experienced by an investor/trader must consider the effects of transaction costs. Thus any model of the return generating process, given the imperfections of "real world" markets, would have to reflect the effects of transaction costs (i.e., bid-ask spread) on measured returns. Also, these transaction costs would be expected to influence the allocation of capital in a market where firms are competing for investment capital. Thus a rational argument can be made that investors will adjust their required rates of return based on expected transaction costs. This is a typical situation in real estate where sellers will mark-up the asking price of their property by an amount equal to the expected brokerage fee. In the case of securities, the portion of transaction costs represented by bid-ask spreads would be expected to influence the return required by investors. Similarly, the return experienced by an investor would be influenced by the magnitude of the bid-ask spread. We might also argue that the existence of the limit order book may result from investors adjusting their buy/sell prices to compensate for the effects of transaction costs on realized or expected returns. The magnitude of those effects is a function of several market related variables.

More recently, Roll (1984), Glosten and Harris (1985), Harris (1986b), and Choi, Salandro, and Shastri (1988) have attempted to measure the magnitude of the bid-ask spread actually paid (the effective spread) by uninformed traders. The important commonality in their research has been the attempt to measure the magnitude of the effective spread by utilizing closing prices. Moreover, their research is motivated by a recognition of the important effects that bid-ask spreads have on investor behavior. Constantinedes (1986) suggests that these proportional transactions costs (i.e., bid-ask spreads) create "no transactions regions." Specifically, investors will make no adjustments to their portfolios when asset prices lie within the no transaction region. Roll (1984) suggested the use of the serial covariance properties of observed prices to estimate effective bid-ask spreads in order to avoid the costly process of collecting actual bid-ask spread data in machine readable form. An important objective for any empirical study utilizing actual bid-ask spread data would be to examine the accuracy of bid-ask spread magnitudes measured utilizing transaction prices.

2.2 Determinants of the Bid-Ask Spread

Demsetz (1968), Tinic (1972) and others have investigated the determinants of the bid-ask spread. Demsetz (1968) observed an inverse relationship between the cost of transacting and trading activity. As the number of trades (volume) increased, the bid-ask spread tended to become smaller. Demsetz also observed that as stock prices increase, the relative cost of transacting also tends to become smaller; the percentage spread declines as price increases. The effective result is an increase in the cost of [equity] capital (and by implication the required rate of return) for small firms (those with low price stocks or small market values of equity) or firms with narrow trading volumes. Implicit in Demsetz' observations is a relationship between bid-ask spreads, stock price, trading volume, and observed returns. Tinic (1971) suggested that Demsetz' (1968) study examined too few variables. Tinic included as determinants of the bid-ask spread certain aspects of the specialists' portfolio inventory position, market structural characteristics, and the economics of the specialist's function. The Tinic model included eight variables (six statistically significant) explaining 84 percent of the variation in bid-ask spreads. Branch and Freed (1977) constructed an equally effective model of bid-ask spread determinants using volume, competition, volatility, and stock price.

An important issue in this study relates to the more complete specification of the returns generating process. Demsetz (1968) established a clear relationship between bid-ask spreads and the cost of capital and by implication the required rates of return. The important determinants of the bid-ask spread have been identified as price, volume, volatility, and the degree of competition. Clearly, models purporting to represent the returns generating process would be misspecified if they did not consider either the bid-ask spread or its determinants. Beaver (1981) has suggested that much of the existing empirical research has been conducted in the absence of a formal model of the returns generating process. The addition of a spread variable to the return generating process would capture an important element missing in the CAPM. Alternatively, the return generating process could be respecified to include the effects of nonsynchronous trading at the microstructure level by measuring returns across the bid-ask spread.

2.3 Specification of the Return Generating Process

Many researchers have observed weak relationships between beta (as a relative measure of risk) and return [ie., Sharpe (1965), Lintner (1965)]. Schwert (1983) has suggested that the statistical evidence supporting a positive relationship between (beta) risk and average returns is surprisingly weak. The basic model used to test this relationship is described by equation (2.1).

$$R_i = a_i + B_i R_m + e_i \qquad (2.1)$$

Where: B_i = beta, a measure of systematic (market) risk
R_i = the average return for security i
a_i, e_i = a constant and random error term, respectively

The inability of the (linear) capital asset pricing model (CAPM) to reflect actual market experience more efficiently may be tied to the manner in which returns and risk have often been measured. Thus the recurrent observation of a misspecified model or incorrectly measured risk attributes may be the result of reliance on returns measured close-to-close. This reliance may be due in large measure to the availability of closing price data in computer readable form.

The effects of the bid-ask spread on the cost of capital and by implication, required rates of return have been established in studies by Demsetz (1968), Smidt (1971), and Tinic (1972). These studies indirectly suggest an alternative method for measuring returns. Assuming for the moment that the cost of capital is affected by the cost of transacting, any model of the returns generating process would be misspecified if it did not include a cost of trading variable. Stoll and Whaley (1983) suggest that "...transaction costs are a missing factor in the single period, two-parameter CAPM." (p. 58). Accordingly, the costs of transferring existing equity should also affect the required rates of return. Thus, we argue that by measuring returns across the bid-ask spread we may capture an important aspect of transaction costs. The obvious question is how should those returns be measured? Most trading activity on the floor of the NYSE is accomplished via the use of "market" orders. Moreover, such orders are the only type that assures a trade. Thus, any realistic testing of trading strategies or returns measurement should assume the use of market orders. Market orders, if not "crossed" with other market orders on the floor of the exchange, are taken to the relevant post to be executed at the quoted ask price for buy orders, and bid price for sell orders. Computing returns would require the use of an asking price on the buy side and a bid price on the sell side.

Some market orders are "crossed" with other market orders, usually at a price within the bid-ask spread. Such matching requires that orders arrive at the relevant "post" at very nearly the same time. Given a random occurrence of crossed trades within the bid-ask spread, the average price of these crossed trades should approximate the mean of the bid and ask price quotes. Returns measured using the mean of the bid and ask price quotes would approximate returns computed from "true" prices as defined by Blume and Stambaugh (1983) and Glosten and Milgrom (1985). The likelihood of crossed-trades occurring on the buy and sell transactions for any given trader is probably low except for securities with relatively large spreads or low volumes. Thus a case may be made for measuring returns using the means of the bid and ask price quotes. Most studies using closing price quotes to compute returns implicitly assume the equivalence of the mean closing price quotes and the mean of the bid and ask price quotes.

Returns could also be measured assuming the use of "limit" orders. Limit orders specify a particular execution price, usually outside the current bid-ask price quotes or equal to either the specialist's bid-price for a limit-buy order or the ask-price for a limit-sell order. If these orders cannot be executed reasonably quickly, they are left with the specialist who enters them in the limit-order book. These orders will eventually be executed at the specified price (assuming that is possible). Thus a "best" case return would be measured by buying at the bid and selling at the ask.

This is the return typically earned by the specialist. A public trader is unlikely, however, to earn this return on a regular basis.

Nearly three-quarters of all trades utilize market orders. Moreover, the specialist participates in two out of every three trades. Thus returns computed from ask-to-bid prices are much more likely to reflect what might actually be earned than returns based on close-to-close prices. Computing returns ask-to-bid (buying at the ask and selling at the bid) embodies a "worst case" assumption. Such an assumption is, however, probably the most realistic for most public (ie., non-exchange member) traders. Computing returns from close-to-close prices, in contrast, introduces a bias of potentially significant but thus far largely unknown dimensions. This study, however, examines the magnitude of this bias.

2.4 Empirical Anomalies

The current study bears on all security market studies that have used close-to-close returns. Much of the empirical research on market behavior has been motivated by tests of market efficiency which use the CAPM to establish risk adjusted returns as a benchmark. This study is, however, particularly motivated by the recent interest in the size, low-priced, and year-end effects as well as the weekend effect. The literature on market anomalies is fairly recent in origin. The seminal papers were written by Banz (1981) and Reinganum (1981) on size effects and by French (1981) and Gibbons and Hess (1982) on weekend effects. These researchers were generally testing the explanatory power of the CAPM when they discovered the results reported in the following sections. The literature in this area is substantial and growing. The following review is not intended to be exhaustive. The remainder of this chapter will review the most germane research reported in the academic literature.

2.4.1 Size/Low Price Effects

Banz (1981) and Reinganum (1981) are frequently cited as the motivators of subsequent research activity on size effects. Size effects address the incidence of excess risk adjusted rates of return accruing to the stocks of small firms over time. The rates of return experienced are in excess of those predicted by most asset pricing models. Also, size effects are most pronounced in studies utilizing daily returns data. Several potential explanations have been offered for these anomalies including the possible misspecification of the CAPM. Roll (1981) has suggested that nonsynchronous trading may explain the size effect anomalies associated with the stocks of small firms or firms with small market values of equity. Alternatively, Roll (1983) suggested that what appear to be excess (positive) returns for small capitalization stocks may have two potential causes: first, the mis-estimation of returns; second, the underestimation of risk, particularly under conditions of nonsynchronous trading. Lakonishok and Smidt (1984) found that stocks in the lowest market value of equity (MVE) decile only traded on average 75 percent of their sample days. This finding is typical of turn-of-the-year trading patterns. Branch and Echevarria (1986) have reported a significant bias in returns when those returns are measured using closing prices. Thus an indication of nonsynchronous trading, underestimation of risk, and overestimated returns may explain the apparent abnormal excess returns of small MVE.

Stoll and Whaley (1983) suggest that the small MVE effect can also be viewed as a low price effect (LPE). Using monthly holding period returns and per share price as the stratification variable they found results similar to Reinganum (1982). The same results have been reported in other research. Both methods utilize stock prices or market values computed from stock prices as the classification variable. Stoll and Whaley (1983) echo other researchers' concerns that the effect could be due to price or other statistical biases.

Blume and Stambaugh (1983) have suggested that the "bid-ask effect" explains part of the size effect. That is, a portion of the effect is due to an estimation bias in computed returns for individual securities. The bid-ask effect imparts an upward bias in average returns computed from closing prices. Moreover, the bias' magnitude is largest in stocks with low MVE. The upward bias in computed returns results from the oscillation of closing (last) transaction prices between quoted bid and ask prices. Unfortunately, they do not offer an explanation for why the bid-ask effect imparts an upward bias in computed returns. Blume and Stambaugh also suggest that the bid-ask effect bias is strongest in rebalanced portfolios and is substantially less significant in buy and hold portfolios. This reduction in bias for buy and hold portfolios results from a "diversification effect" not present in rebalanced portfolios. This creates some confusion. Rebalancing means maintaining an equal dollar amount invested in each asset held in a portfolio by "rebalancing" at the end of each period. Accordingly, stocks which have gone up in price must have some portion sold so as to maintain a fixed dollar value invested; stocks which have gone down in price must have additional shares purchased in order to maintain the same proportions (equal weights). This rebalancing behavior does not present a problem in a perfect market; i.e., no transactions costs. The effects of rebalancing can be accomplished (de facto) by simply computing the daily return of the portfolio as the cross-sectional daily average return of all securities in the portfolio and then utilizing these daily portfolio returns to compute the geometric holding period return. The result appears as a rebalancing to equal weights. The lack of a "diversification effect" is unlikely to result in a bias or bid-ask effect. A portfolio composed of randomly selected securities which are bought and held does not necessarily obtain better diversification effects than a series of randomly formed portfolios over the same time frame.

Blume and Stambaugh (1983) characterize the magnitude of the estimation bias in terms of return differentials between buy-and-hold portfolios and rebalanced portfolios. They demonstrate that the bias in calculated returns is most noticeable in "rebalanced" portfolios. Blume and Stambaugh show that the size effect reported by Reinganum (1981) is reduced by one-half when buy-and-hold portfolio returns are calculated. This reduction in the magnitude of the size effect is attributed to the attenuation of the bid-ask effect via use of buy-and-hold portfolios.

Roll (1983) has shown that the method used for computing mean portfolio returns in size effect studies lead to different results. The method used to compute mean returns is partly responsible for anomalous excess returns accruing to small firms or firms with small market values. These results stem from the autocovariance properties of portfolio returns. Specifically, if positive serial dependence is present in portfolio returns, arithmetic average returns (AR) will be larger than returns for buy-and-hold (BH) or rebalanced (RB) portfolios. Thus any size effects will be larger if a simple AR return is used in contrast to BH or RB returns. Also, for short-term holding periods (ie., daily or weekly) use of arithmetic average returns or rebalancing strategies will overstate returns compared to buy-and-hold.

The "bid-ask effect", in the Blume and Stambaugh (1983) study, results in a mis-estimation of the "true" prices (and by implication true returns) when the average of observed prices is computed. They define the true price as the average of the closing bid and ask price quotes. This definition differs from the true price as defined by Glosten and Milgrom (1985). The latter define the "true" price as the price which would prevail under conditions of symmetric information. The two definitions evolve from complementary views of the market microstructure. The Blume and Stambaugh (1983) view implicitly recognizes the imperfection of real markets; stocks trade at values other than their theoretical intrinsic values. The mean of these observed transaction prices should, however, be equal to the intrinsic value. The intrinsic value is the result of an informationally efficient market and is termed the "true" value by Glosten and Milgrom (1985). An underlying drift in the daily mean of the closing bid and ask price spread over a period of time is a potential source of error or bias. This is readily observable in a bull or bear market. A tendency of last trade prices to occur on the ask-side (bull market) or the bid-side (bear market) could result in a difference between the mean of observed closing prices and the mean of the closing bid and ask prices.

Intuitively, if transactions occur symmetrically at the bid and ask levels and randomly within or outside the bid-ask spread, the mean of all transaction prices in any security should equal the true price. The bias resulting from oscillations of quoted closing prices which differentiate the mean of the closing price quotes from the mean of the closing bid and ask prices suggest some degree of measurement error or inefficiency. Moreover, the bias could be greater if the price series were experiencing a drift. The magnitude of the drift would be the difference between the mean closing price and the mean of the closing bid and ask price quotes divided by the number of observations. The presence of any drift in values, up or down, would be reflected in the distribution of transactions at the bid, ask, inside or outside the bid-ask spread at the close of trading. Thus an upward or downward bias might be found in computed average returns which are subject to an underlying drift moment. If the "bid-ask" effect bias is partly responsible for the size effect, then the bias should be relatively large for low price stocks and stocks with low trading volumes. This result is due to the magnitude of the relative spread which tends to be higher for those stocks. Blume and Stambaugh (1983), however, offer limited empirical evidence for their hypothesized bid-ask effect. Their sample consisted of one day's closing bid and ask price quotes for 332 stocks on the NYSE with bid prices less than $8.00. Thus their results may only be valid for a static cross-section of stocks and may not reflect the dynamic behavior of this bias over a longer period of time. Also, the Blume and Stambaugh study does not examine any other effects due to volume differences, price volatility, or the magnitude of the bias as stock prices get larger. These additional variables would be useful in any study examining the determinants of the bias.

2.4.2 January Effects

The sample of December and January bid-ask spreads facilitates review of the January effect research. The January effect is the apparent tendency of stocks which experienced year-end lows in December or large declines in the preceding year to experience positive returns in January. Rozeff and Kinney (1976), Branch and Freed (1977), Dyl (1977), Keim (1983). More recently Branch and Chang (1985), and a host of others observe seasonal effects in stock returns. Keim (1983), studying the size effect, observed that 50% of the abnormal excess (positive) returns ascribed to the size effect occur in the month of January; 26% occurs in the first week in January and 11% the first day. As a consequence, the January effect and the size effect may exhibit some degree of inter-relationship. The two effects may be acting together. Brown, Kleidon and Marsh (1983), using monthly returns data report that the January effect is unstable, but still positive. Keim (1986) observes that the magnitude of the size effect differs across days of the week and months of the year. Accordingly, the magnitudes of the effects may be influenced by whether the year ends or starts on a Monday or a Friday. Keim (1986) also observes that the inclusion of dividends imparts a strong upward bias if a sufficient number of companies in the sample are paying dividends. Few companies in the lowest price decile of this study paid dividends either during the 42-day test sample one or the 43-day confirmation sample. However, all returns will include dividend yields.

2.4.3 Weekend Effects

Cross (1973), French (1980), and Gibbons and Hess (1981) have reported the apparent tendency of stocks to experience negative returns on Mondays. This behavior is inconsistent with the weak form of the efficient market hypothesis. One potential explanation for the weekend effect may be the systematic occurrence of ex-dividend dates on Mondays. These studies did not control for the incidence of ex-dividend dates. Thus any study of a weekend effect would need to control for ex-dividend effects. The French (1980) study reporting a weekend effect used a data sample for Standard & Poor's Industrials stocks that did not include dividends. Thus, the presence of a substantial negative return on Mondays would be expected in the absence of correcting the return computation algorithm for ex-dividend-day price adjustments. French observes that his results may "...simply reflect a systematic pattern in 'ex-dividend' dates." More recently Philips-Patrick and Schneeweis (1987) find that ex-dividend price effects distort weekend effect findings and offer an essentially theoretical proof.

2.5 Microstructure Price Behavior and Autocorrelation

An important concern of security market researchers is the extent to which serial price correlations affect the results of empirical studies. The general theoretical assumption is that prices are randomly drawn from a known distribution. The theoretically expected results are independently distributed returns. An important and unresolved question is how returns are related to where stocks close in relation to the bid-ask spread. Neiderhofer and Osborne (1966) reported the presence of serial dependencies in intraday price movements. The presence of autocorrelation in sequential price series is a statistically troublesome phenomenon.

About twenty years ago Niederhofer and Osborne found a tendency for intraday transaction prices to move up and down (between the bid and ask price quotes) thereby producing an apparent degree of negative serial autocorrelation in successive price changes. An earlier study by Niederhofer (1965) reported the apparent clustering of limit order prices at whole dollar values. The important result is the negative autocovariance property of intraday sequential transaction price series. This property reflects the manner in which stock trades occur when markets are discontinuous. An important explanation for this behavior is the activity of the specialist. In markets characterized by discontinuous trading, the specialist alternatively buys and sells from his (her) own account or holds orders left by other brokers until a matching order arrives at the trading post. The result appears as a series of up and down movements of transaction prices. The assumptional structure of the asset pricing models holds that these oscillations are random. The first order negative covariance properties would indicate that successive prices are not randomly drawn as specified in the theory.

2.6 Market Indexes and Stock Performance

A substantial body of literature has addressed the problems of the capital asset pricing model (CAPM) and market efficiency. Roll (1977) observed that the choice of index will influence any results obtained when the CAPM is used to measure market efficiency. Roll also suggested that the market portfolio should contain all assets. Statistical sampling techniques allow for the use of very small samples in order to ascertain the characteristics of the population. In like manner, an index may be constructed using a small set of securities which captures the character and trend of the stock market. The DJIA has been selected for this purpose.

Closing prices (last trade of the day) are used to compute price changes of securities that are reported in the newspapers and elsewhere. These same closing prices are also used to compute the values of market indexes and the change in those values. The last trade of the day for a particular issue is, however, a rather imperfect index of the market for that stock at day's end. The last trade could have taken place any time during the day (including the opening). Moreover the bid and ask levels could have moved appreciably by the end of the day. Without a transaction, however, the reported close will not reflect this movement. Most of those who follow the market primarily focus on the closing or last trade prices to determine what is happening to the market index and individual security prices. Also, most measures of stock price volatility (such as betas and nonmarket risk measures) utilize prices and price changes based on the close.

CHAPTER 3

HYPOTHESES

3.1 Research Questions

The basic questions discussed in this chapter are:

Question 1a: How much measurement error is induced in the estimate of the true price when closing transaction prices are utilized rather than closing bid and ask price quotations ?

Question 1b: What is the magnitude of measurement error in computed holding period returns when closing prices are used rather than expected closing prices estimated from closing bid and ask prices ?

Question 2a: To what extent is the evidence of the size effect anomalies the result of misspecification of the return generating process ?

Question 2b: To what extent is the evidence of weekend effects the results of misspecifications of the return generating process and other market regularities ?

Question 2c: To what extent can we identify potential causes of the January effect and can size effects be separated from the January effect ?

Question 3: How efficient are market estimates of relative risk (beta) when alternative price structures are utilized to estimate beta ?

This chapter begins with the development of the rationale underlying the construction of alternative price and return measurement models to be utilized in testing the persistence of the several anomalies reviewed in the literature. The assumptions regarding the nature of observed prices will also be tested to determine the extent of their viability as estimates of true prices. The specification for each of the three return generating process models is based on the assumed transaction price level. The models may indicate that some portion of the reported anomalies result from the misspecification of the price and return measurement models used in almost all security market research. The key to much of the following discussion is the manner in which the asset pricing models have been constructed and how biases and measurement errors may have resulted in findings inconsistent with market efficiency.

3.2 Observed Prices as True Prices

Demsetz (1968), Blume and Stambaugh (1983), and Glosten and Milgrom (1985) have addressed the notion of the "true" price. The true price represents the intrinsic value of the underlying firm's expected income streams on a per share basis. Demsetz characterized the true price as the price which would prevail in a perfect market. More recently, Blume and Stambaugh and Glosten and Milgrom have defined the true price as the simple average of the closing bid and ask price quotes in an efficient market. Most market studies assume that the closing price is an equivalent of the true price construct. If a significant and systematic difference exists between the observed price and the true price, then some or all of the reported anomalies may be the result of measurement errors induced by the use of closing prices. Blume and Stambaugh suggest that a difference between true and observed prices does exist and results from a "bid-ask effect." The magnitude of the error can be readily obtained as the difference between the closing price and the mean of the closing bid and ask price quotes.

The following discussion draws heavily from Blume and Stambaugh (1983) and forms the development rationale for the test hypothesis. Let P_t represent the true (expected closing) price and p_t represent the observed (average closing) price. For purposes of this study, and in order to maintain consistency with prior studies, P_t is defined in equation (3.1) as the mean of the closing bid (P_B) and ask (P_A) price quotes;

$$P_t = (P_{B,t} + P_{A,t}) / 2 \quad (3.1)$$

Errors in estimating security returns arise when P_t and p_t are not equal. Accordingly, the closing price is modeled by Blume and Stambaugh in equation (3.2) as;

$$p_{i,t} = [1 + \delta_{i,t}] P_{i,t} \quad (3.2)$$

Solving for $\delta_{i,t}$;

$$\delta_{i,t} = [p_{i,t} / P_{i,t}] - 1 \quad (3.3)$$

The term $\delta_{i,t}$ defines the [percentage] factor by which the observed closing price ($p_{i,t}$) differs from the expected closing price ($P_{i,t}$). Blume and Stambaugh assume that $p_{i,t}$ is equal either to the closing bid or the closing ask price. Since many, perhaps most, stocks have bid-ask spreads sufficiently large to permit a close between the bid and the ask, we estimate the empirical value of $\delta_{i,t}$ as $e_{i,t}$. We will then compare Blume and Stambaughs $E(\delta)$ to the empirically estimated $E(e)$. Accordingly, we model $e_{i,t}$;

$$e_{i,t} = [p_{i,t} / P_{i,t}] - 1 \quad (3.4)$$

We will test to see if $E\{e_{i,t}\}$ is nonzero. Blume and Stambaugh (1983) assumed $\delta_{i,t}$ to be independently distributed across t and independent of $P_{i,t}$ for all t. We do not make the same assumption about the covariance of ($e_{i,t}$, $e_{i,t+1}$).

Results reported by Blume and Stambaugh (1983) did not address the magnitude of this error. This omission may be due to the limited amount of data available to them. Their study was based on one day's data for closing bid and ask price quotes. The current test examines 42 days of data for 1134 companies in the test sample and 43 days of data for 1205 companies in the verification sample. A second problem with the Blume and Stambaugh suggestions is that they do not consider the effects of an underlying drift in the true price as market estimates of intrinsic values change over time. At question is the identity of the mean observed closing price and the mean of the closing bid and ask prices. The effects of any underlying drift in the true price will be reflected in slightly higher variance estimates for both price series. This underlying drift is not expected to have an adverse impact on the statistical tests.

Hypothesis 1--True versus Observed Prices

Hypothesis 1: The mean of the observed closing price is equal to the mean of the closing bid-ask price quotes. Specifically, the $E\{e_{i,t}\} = 0$.

This test has two parts. In the first part we will test the parameter estimates for all stocks in each of the research samples. In the second part we test the parameter estimates for each price-classified decile. The two sets of tests are necessary. An objective of this phase of the study is to ascertain the magnitude of the bias across different price ranges. Failure to reject the null hypothesis will imply that the two measures are the same. Failure to accept the null hypothesis will have more important implications for empirical anomalies and market efficiency.

3.3 Observed Returns as True Returns

Blume and Stambaugh (1983) suggest that the "bid-ask effect" results in upwardly biased estimates of security returns. The bias results when closing prices, instead of "true" prices, are utilized to compute [daily] returns. Blume and Stambaugh estimate the "...potential magnitude of the bid-ask bias" (p390) using equation (3.5);

$$\sigma^2(\delta) = E\{(P_A - P_B) / (P_A + P_B)\}^2 \qquad (3.5)$$

The Blume and Stambaugh suggestion that equation (3.5) defines the magnitude of the bid-ask bias requires amplification and correction. Equation (3.5) is really a point estimate of the [maximum] variance of the difference between the expected (true) closing price and the observed closing price. The numerator $(P_A - P_B)$ is equal to the bid-ask spread; the denominator $(P_A + P_B)$ is equal to two times the true price. Equation (3.4) may be re-written as;

$$\sigma^2(\delta) = (\emptyset / P)^2 \qquad (3.6)$$

where: $\emptyset$ = one-half the bid-ask spread
P = the true price computed as $(P_A + P_B)/2$

In effect, $\sigma^2(\delta)$ is a conditional estimate of $s^2(e)$; the variance of the error term described by equation (3.4). Moreover, equation (3.5) explicitly assumes that stocks will close at the bid (P_B) or the ask (P_A) price. This assumption is reasonable for stocks trading with a spread of 1/8 point. This is the case for most stocks in the lowest price decile. Blume and Stambaugh estimate the average value of $\sigma^2(\delta)$ as .051% (based on one day's data for 332 NYSE-listed stocks). This study will test the generality of that result. We note that the magnitude of the bid-ask bias in returns estimated by equation (3.5) is conditioned on an assumption of a zero drift in the underlying price trends. We will show that the Blume and Stambaugh estimate of the bid-ask bias in returns is incorrect when security prices are subject to drift.

Blume and Stambaugh (1983) also fail to test the significance of the difference between returns computed using closing prices and returns computed using the mean of the closing bid and ask quotes. Recall that in an efficient market, the bid and ask quotes should straddle the true price. Accordingly, we model two return series; a true series and an observed series. The difference between the two series represents the magnitude of the bias resulting from the bid-ask effect. The true return ($R_{i,t}$) for any security i for period t is modeled; ($D_{i,t}$ = dividend)

$$R_{i,t} = \{ (P_{i,t} + D_{i,t}) / P_{i,t-1} \} - 1 \qquad (3.7)$$

and the observed return ($r_{i,t}$) is modeled;

$$r_{i,t} = \{ (p_{i,t} + D_{i,t}) / p_{i,t-1} \} - 1 \qquad (3.8)$$

and the error process is modeled;

$$\Phi_{i,t} = R_{i,t} - r_{i,t} \qquad (3.9)$$

If the bid-ask effect is not a factor in return measurements, we expect that $E(\Phi_{i,t}) = 0$. Any significant differences between the two computed return series implies a degree of return measurement inefficiency. This inefficiency may be the cause of a portion of the return estimation problems observed in tests of the asset pricing models. Also, this inefficiency may underlie the explanations for research results demonstrating anomalies in security returns.

Hypothesis 2--True Returns versus Observed Returns

Hypothesis 2: The mean of the observed returns for individual securities is equal to the mean of the estimated true return. Specifically, $E(\Phi) = 0$.

Blume and Stambaugh (1983) suggest that $E(r_{i,t}) > E(R_{i,t})$. This test will explore whether this assertion is true and more importantly if the difference is significant. The results of this test, as in the previous test, will have important implications for the assumptional structures of the asset pricing models.

3.4 The Size Effect

The size effects reported by Banz (1981), Reinganum (1981), and Keim (1983) may be statistical artifacts of the method used to calculate returns. Blume and Stambaugh (1983) and Roll (1983) have suggested that size effect findings are influenced by the methods used to measure mean portfolio returns. Blume and Stambaugh ascribe the magnitude of the findings to "bid-ask effects" which are more pronounced in rebalanced portfolios. Roll suggests that the method used to compute mean returns contributes to size effect findings. Both agree that the affects are minimized, but still present, in buy/hold portfolios. Size effects may also be the result of a misspecification of the return generating process. An important difference between this study and prior studies is that the current study utilizes stock price as the stratification variable instead of the market value of equity. Stoll and Whaley (1983) have suggested that the size effect and the low price effect are substantially the same. Accordingly, we examine the character of the size effect by utilizing the prices rather than market value of equity. Clearly low price and low market capitalization are not identical; one is no more than an imperfect proxy of the other. Accordingly, We expect some loss of generality as a result of this modification.

In an efficient market, the observed closing price is assumed to be an identity with the expected closing (true) price. We have suggested earlier in this chapter the possibility that the two may be different. Even if the two are not significantly different, a problem remains stemming from the implicit assumption that the observed closing price is in all instances obtainable by a public trader. The problem is tied to the measurement of returns. If the expected closing price is identical to the price obtainable by a public trader, then the return generating process would be modeled as;

$$R_{i,t} = [\ (p_{i,t} + D_t) \ / \ p_{i,t-1}\ ] - 1 \qquad (3.10)$$

Note that equation (3.10) assumes a substantive identity between the true and observed prices ($P_{i,t} \approx p_{i,t}$). This assumption is not equivalent to implying that $p_{i,t}$ is a good representation of an obtainable price for a public trader using a market order. Earlier, we reviewed the problems and costs incurred when markets do not continuously trade. The result is an additional cost for immediacy services (the bid-ask spread). This cost is equal to one half of the bid-ask spread for a buy or sell order; we defined $\emptyset$ to equal one half of the spread. Assuming that the most prevalent order used for trading securities is the market order, the return process should be modeled;

$$r_{i,t} = [(P_{i,t} - \emptyset) + D_{i,t}) / (P_{i,t-1} + \emptyset)] - 1 \quad (3.11)$$

Note that by the normal operation of the market, a market order trader buys at the ask and sells at the bid. Accordingly, $bid_{i,t} = P_{i,t} - \emptyset$ and $ask_{i,t} = P_{i,t-1} + \emptyset$.

$$r_{i,t} = [(bid_{i,t} + D_{i,t}) / ask_{i,t-1}] - 1 \quad (3.12)$$

The returns computed using equation (3.12) are to be compared to returns computed using equation (3.10). Two sets of returns will be computed; December and January for each price stratified decile . Keim (1983) reports a significant difference between January returns and returns for other months of the year between firms in the smallest and largest market value of equity deciles. Similarly, we will compare average December and January returns in testing the persistence of low price effects. The low price effect will also be tested using returns generated bid-to-ask (simulating a limit order execution).

Hypothesis 3--Effects of Alternative Specifications of the Return Generating Process on Findings of Low Price Effects.

Hypothesis 3: The low price effect is a statistical artifact of the return generating model used to compute returns.

Tests of the low price effect under alternative specifications of the return generating process underscore the importance of the biases found in returns generated from closing price quotes. The fundamental question is; are the assumptions made about the return generating process adequately specified when they rely on closing prices? We have earlier described the manner in which returns are most likely to be earned; ie., ask-to-bid with a market order, and less probably bid-to-ask with a limit-order. The most important return process model must be the ask-to-bid model. The results of this study should help increase our understanding of the extent to which biases in estimated returns underlie the causes of observed empirical regularities.

One additional set of comparisons will be made. Roll (1983) demonstrates that the method used to compute mean portfolio returns in size effect studies determines to a significant degree the magnitude of the size effect. Accordingly, this study will compute and compare returns utilizing the three methodologies outlined by Roll; Arithmetic returns (AR), Buy and Hold returns (BH) and Rebalanced returns (RB). The three mean portfolio return measurements are modeled in equations (3.13), (3.14), and (3.15).

$$R_{AR} = 1/N\tau \cdot [\ \Sigma_i\ \Sigma_t\ R_{i,t}]^{\tau} \qquad (3.13)$$

$$R_{BH} = 1/N \cdot \Sigma_i \cdot [\ \pi_t\ R_{i,t}\ ] \qquad (3.14)$$

$$R_{RB} = \pi_t\ [\ 1/N \cdot \Sigma_i\ R_{i,t}\ ] \qquad (3.15)$$

Where: N = the number of securities in the portfolio
τ = the total number of periodic returns in the sample
π = a product of τ-periodic returns

Equations (3.13) and (3.14) specify two alternative methods for computing mean equally-weighted portfolio returns. Equation (3.13) is a simple periodic (i.e., daily) average return computed across N securities for τ periods. This periodic average is then raised to the

τth power to compute the total portfolio return for τ periods. Equation (3.14) demonstrates the actual investment results achieved when equal dollar amounts are invested in N securities and held for τ periods. Equation (3.15) is the return an investor would earn if equal dollar amounts were invested in N securities and maintained by rebalancing at the end of each period, $t = 1,\ldots,\tau$. Research use of equation (3.15) implicitly ignores the transactions costs which would be incurred as a result of periodic rebalancing of the amounts invested in each security held.

Twelve different estimates of portfolio returns are possible. Discrete returns may be computed with equations (3.7), (3.8), (3.12), and a variation of (3.12) reflecting the use of a limit order and portfolio returns computed with equations (3.13), (3.14), and (3.15); 4 x 3 = 12. Roll shows that (AR) returns are greater than (BH) in the presence of positive serial correlations in portfolio returns. Roll also shows that (RB) returns are also larger than (BH) returns. These results obtain from the behavior of the error process in computed returns.

3.5 The Weekend Effect

The weekend effect has been documented in studies by Cross (1973), French (1980), and Gibbons and Hess (1981). In each study returns generated from closing prices have been utilized. These studies have generally lacked adequate controls for potential biases in Friday-Monday returns caused by any tendency for large numbers of stocks to go ex-dividend on Mondays compared to other days of the week. Also, these studies have not examined the effects across different levels of price and under alternative specifications of a return generating process. The use of closing prices to estimate returns are known to involve significant estimation biases. These biases may underlie findings of weekend effects in stock returns.

This study will reexamine the weekend effect utilizing two separate methodologies. First, Friday-to-Monday and Monday-to-Tuesday returns will be estimated using equations (3.10) and (3.12). Differences between Friday-Monday and Monday-Tuesday returns will be tested for significance. Second, the effects will be examined for each price stratified decile. Dichotomization of the sample permits more discrete information to be established on the nature of the effect. Weekend effects may also be the result of a misspecification of the return generating process. Alternatively, the weekend effect may not be uniform across different stock price ranges. Finally, the weekend effect may be the result of mis-estimations of true prices and returns by observed prices and returns.

Hypothesis 4--Causes and Explanations of the Weekend Effect

Hypothesis 4a: The weekend effect is a statistical artifact of the return generating process used to compute returns.

Hypothesis 4b: The weekend effect is uniform across all securities regardless of price range or dividend payment artifacts.

Examination of these two hypotheses will permit a more structured and complete study of the weekend effect in stock returns. Earlier studies reporting weekend effects have generally failed to examine all the available information fully and have as a result been unable to explain adequately the probable causes of the anomaly.

3.6 The January Effect

Several studies have noted the apparent tendency of stocks experiencing depressed prices in December to experience substantial gains in January. These findings may have been confounded by size effects or other possible anomalies. Substantial disagreement permeates the various papers on the subject. The current study is principally engaged in examining the biases induced in returns when those returns are measured using closing prices rather than bid and ask price structures. The nature of the data samples, however, permits a partial examination of this effect. Accordingly, the first (lowest) and tenth (highest) price deciles are subdivided into quintiles. Stocks are assigned into each quintile on the basis of December returns. Stocks with the poorest December performance are assigned to quintile one, those with the best December performance to quintile five. These quintiles are then utilized to contrast December and January returns. Some research has reported that stocks experiencing large declines in December experience large gains in January. Other research has shown that stocks with large positive returns in December experience additional gains in the new year. Also, price and volume data may be examined to test the strength of the January effect. No testable hypotheses are offered due to the limitation imposed by the time period of the data samples. This particular area, however, offers a fertile ground for additional research with an expanded data set.

3.7 Alternative Price Specification Effects on Indexes

A final area of interest in this study is the construction of a market index using prices other than the closing price reported in the financial press and on the data tapes. Of particular interest are the magnitudes of any differences noted between alternative index construction methods and measures of risk (beta). The use of closing prices may result in a more volatile index and/or more volatile estimates of risk when the market model, equation (3.16), is utilized. The interest in this particular area stems from the frequent identification of a misspecified asset pricing model or problems arising from mis-estimation of returns and variances. This particular part of the study may not lend itself to meaningful statistical testing due to the limited time-frame of the sample and the problems attendant to getting good estimates of beta. The results to be described in this study should be treated accordingly. Also, no part of this inquiry is meant to imply an interest in forecasting returns. Our principal objective is to determine whether more efficient estimates of beta may be attained by utilizing alternative price structures.

The current study will examine the effect of using the mean of the closing bid and ask price quotes to generate returns and estimates of beta (using the market model). A recurrent observation in the literature on size effects is that these effects are to some degree the result of misestimations of risk and/or over-estimations of return. Elimination of potential sources of estimation error should improve the efficiency of beta estimates. Returns will be generated using equations (3.7) and (3.8). Betas will be estimated using the market model as defined by equation (3.16);

$$R_{it} = \alpha_i + \beta_i \cdot R_{mt} + e_{it} \qquad (3.16)$$

Betas estimated by using returns computed with equation (3.7) will be compared to betas estimated with returns computed with equation (3.8). We would expect that the latter would be more efficient than the former.

Hypothesis 5--Efficiency of Beta Estimates

Hypothesis 5: Estimates of betas are sensitive to errors induced by misestimations of true prices in computing returns.

An additional set of betas may be estimated using the returns estimated from equation (3.12) for all securities in the sample. This study recognizes that these estimates as well as the estimates using equations (3.7) and (3.8) are deficient in that they only cover a very limited time sample. These estimates are made for purposes of determining if increases in risk estimation and pricing efficiency are possible when alternative price constructs are used in estimating returns. As stated in the beginning of this chapter, a substantial portion of the deficiencies of the asset pricing models, the CAPM in particular, may be the result of numerous small sources of errors in estimating security returns. The reduction of these sources of error may be achieved via corrections in the specifications of the price and return generating models.

CHAPTER 4

METHODOLOGY AND DATA

This chapter begins with an outline of the research design. Special emphasis is placed on discussing the significance of the test procedures for the research hypotheses. A description of the samples follows. A discussion of measurement procedures and statistical analysis completes the work of the chapter.

4.1 Research Design

The hypotheses to be tested in this study call for two basic research designs. Hypotheses 1, 2, 3, and 4 require the computation of means and variances. Hypothesis 5 requires the regression of individual security returns against a proxy for the market portfolio using alternative price and return generating process specifications. The form of the tests are rather simple. The implications of those tests are another matter.

4.1.1 Hypothesis 1 and 2

These hypotheses address important questions raised in security market research regarding the equivalence of observed prices and returns and the estimates of true prices and returns constructed from closing bid and ask price quotations. In an efficient market the bid and ask price quotes should straddle the true price. Any significant deviation of closing prices from the mean of the closing bid and ask prices becomes important in light of the operation and sensitivity of the asset pricing models. The problems in the use of the asset pricing models to test market efficiency are well documented. At issue in this section of the study is the magnitude of the errors in the price assumptions and whether those errors are systematic. Accordingly, we test to see if errors are significantly different from zero, or if two sample means are the same or significantly different. The test of hypothesis 1 will indicate whether the mean of an observed series of closing prices is equal to the mean of the closing bid and ask quotes. The Milgrom, et al, price theory holds that the expected closing price should be approximately equal to the true price. The expected closing price is assumed to be the average of observed closing prices over some unspecified time period for any randomly selected security. Any significant differences could result in potential errors in measuring returns. The validation of that finding is made by testing the returns generated from the observed price series against returns computed utilizing the closing bid and ask prices. The test of hypothesis 2 is designed to indicate whether the observed returns are equal to the true returns. Both tests are used to determine the extent of measurement errors in the variables used to test market efficiency and the asset pricing models. The problem of measurement errors is non-trivial even in samples as large as those typically used in security market research.

4.1.2 Hypotheses 3 and 4

Hypotheses 3 and 4 address specific anomalies reported in the literature. Hypothesis 3 examines the persistence of the size effect when alternative specifications of the return generating process are utilized. The market value of equity is generally used to study the small firm or size effect. A study by Stoll and Whaley (1983) confirmed findings by Banz (1981) and Reinganum (1981) reporting the inverse relationship between market value of equity and risk-adjusted returns. Stoll and Whaley also demonstrate that price per share exhibits the same characteristic. Accordingly, price per share is utilized to examine the dynamics of the size effect. Separate return series are generated for December and January. Results reported by other researchers {i.e., Keim (1983)} indicate that the returns of these two months are significantly different. Accordingly, we test the data sample using the same return generating model specification in order to verify that the anomaly is present. The same data set is then tested with returns measured in different ways to determine whether or not the anomalies persist and if they do exist, whether the effects are attenuated or magnified.

The size effect anomaly will be tested in a manner similar to Reinganum (1981). The sample will be divided into deciles using price as the classification variable. Testing of the sample will be made to ascertain the strength of the difference between December and January returns using close-to-close prices. One important difference between this and prior studies is the size of the data sample. Prior studies have typically used 15 to 20 or more years of data. The current study has two months of data in the test sample and an additional two months in the verification sample. The enormity of effort required to collect just one month of closing bid-ask quotes in computer-usable form restricted our sample size. The implications of any results found using this data sample are accordingly limited. This study will be able to examine returns in the month of January relative to December returns. Keim (1983) has reported that a substantial portion of the size effect (excess returns for small capitalization stocks) occurs in January and the bulk of it in the first week in January. The current data sample allows these findings to be confirmed. The size effect may then be tested using the alternative return measures from chapter III. The size effect will be tested primarily for the differences between the average daily returns when different methods are utilized to compute portfolio average returns. Specifically, Roll (1983) suggested that the manner in which returns are measured explain part of the effect. Roll discusses three methods for measuring portfolio returns; averaged returns (AR), buy-hold returns (BH) and rebalanced returns (RB). Given the observed presence of negative autocovariance in individual security returns and positive covariance in portfolio returns, testing for the size effect will utilize the BH method as the primary test vehicle. Roll (1983) and others have reported this method yields the smallest, but still significant, size effect. The price deciles become the buy-hold portfolios. December returns will be compared to January returns using the three return calculation methods discussed in chapter III. Student-t tests will be used to test if the differences are statistically significant.

Hypothesis 4 addresses the weekend effect anomaly in much the same manner as hypothesis 3. The weekend effect is important as it forms a major violation of the random walk hypothesis. Systematic negative returns accruing on Mondays in contrast to other days of the week are potentially troublesome, particularly for studies using monthly or weekly data. The prevalence of Monday observations in the data set would tend to bias downward the estimated returns. Also, variance estimates might be upwardly biased unless corrective measures are taken. The results could appear as excess risk adjusted returns. The test procedures for the weekend effect require three separate phases.

First, the returns are tested for dividend effects. A systematic pattern of ex-dividend dates falling on Mondays could result in the observed negative returns . A second possibility is that the effect is not universal. It may be stronger in some price categories and not in others. In the second phase, we gauge the strength of the anomaly across price stratified data. The effect may be significant in some deciles and not in others. As a consequence, a few securities may be able to influence overall results. Alternatively, the effect may be the artifact of the means used to measure returns. In phase three we test the returns generating model specification hypothesis. The weekend effect may be an artifact of the method used to measure returns. An important thread throughout the current study is the importance of this specification. The strength of previously reported anomalies will be substantially attenuated when the return generating process is respecified.

The weekend effect will be tested by examining the difference between the average of returns generated Friday-to-Monday (or Thursday-to-Monday for the holiday weekends) and average Monday-to-Tuesday returns using equations (3.7),(3.8), and (3.12) in chapter III to compute each daily return. Statistical tests of the difference between the two sets of average returns will confirm the presence of a weekend effect in the sample data. The data sample will then be subdivided into dividend and non-dividend paying stocks to test further the nature of the anomaly. If the weekend effects anomaly is sensitive to the presence of ex-dividend day effects, then weekend returns should not differ significantly from weekday returns when dividend paying stocks are excluded. The weekend anomaly may also be an artifact of the manner in which returns are measured; in addition to or exclusive of ex-dividend day effects. One additional examination of the data is possible. If ex-dividend day frequency distributions are non-random, then we should observe a non-random pattern in daily price effects.

The tests in this section are strongly related to the first set of tests described in section 4.1.1. The common objective of the first four hypotheses is to gauge the behavior of anomalies and errors when alternative specifications of price structures are imposed and when alternative specifications of the return generating process are utilized. A third anomaly, the January effect, is also examined

The January effect refers to the apparent tendency of stock prices depressed in December to experience substantial gains in January. These effects may be compounded by low price effects. Stocks which have reached lows are very likely to fall in the lower price deciles. Any stock experiencing a low in December may experience a substantially positive move in December. Moreover, the magnitude of the January "recovery" may be a function of the price level. An appropriate test would be to subdivide securities within each decile on the basis of December performance. Stocks in the first and tenth price deciles are rank-ordered on the basis of December returns into quintiles. January returns are compared to December returns by quintile to examine the extent of the January effect and to determine if the January effect is sensitive to price level. Also, stocks which have not reached year end lows in December are equally likely to experience substantial gains in January. Since the two effects may be difficult to separate, this study will examine the distribution of December returns against January returns. Accordingly, two sets of returns (December vs January) for the lowest and highest price deciles will be examined using mean quintile return differentials. The differentials will be tested to see if they are significantly different from zero. The resulting analysis should permit some generalizations to be made about the January effect.

4.1.3 Hypothesis 5

Hypothesis 5 brings the process of this study to an interim conclusion. The results to be presented in the following chapter will raise several questions about the methodologies used in constructing the asset pricing models and in the relevancy of the assumptional structures which support them. In Hypothesis 5 we test to see if more efficient estimates of relative (beta) risk are possible when measurement errors in the variables are minimized. Accordingly, we estimate beta utilizing the simple market model and two different price series. The first price series is the usual closing price series. This series is used to compute returns for individual securities and the proxy for the market portfolio. All securities in the sample are used to construct the market index. The second price series is constructed by calculating the means of the closing bid and ask quotes. In effect, the second price series enables us to estimate the true return. We assume that such a return is capable of being estimated using empirical data. The assumption is non-trivial. If the notion of an efficient market is to be verified empirically, then this series should yield improved estimates of beta. If this series does not improve the efficiency of the model, then other constructs might be required in order to improve or respecify the current asset pricing models.

4.2 The Research Sample

The research data sample is divided into two sub-samples. The first test sample (TS1) includes market data for 1134 stocks traded on the NYSE over the period from December 1, 1981 through January 29, 1982 (42 days). The second test sample (TS2) covers the period December 1, 1982 through January 31,1983 (43 days), and contains market data for 1205 stocks. TS1 includes daily open, high, low, closing, bid, and ask price quotes, and trading volume; TS2 consists of bid, ask, and closing price data. Open, high, low, close, and volume data were extracted from the daily range tape prepared by Fitch for the NYSE. Closing bid and ask price quotes for each day in the data sample were provided by Fitch's "Stock Quotations on the New York Stock Exchange". TS1 information on ex-dividend dates and dividend amounts were manually inputted from Standard and Poor's Dividend Record (1982). TS2 information on ex-dividend dates and distributions were extracted from the CRSP daily master tape (1987). The resulting data samples represent a substantial increase in the amount of bid and ask price data from that used in prior studies. The data samples contain no preferred stocks, or warrants. Also, the return computation algorithms have been modified to allow for the ex-day effects of stock dividends or stock splits during the two-month time frame covered by the samples. A check has been made on the extent of missing observations. For TS1, out of 47,292 transaction line items, 348 were missing data on the range tape (.74%). A smaller percentage of issues are missing data in TS2. Issues missing three or more successive days of closing, bid, or ask price data were excluded from the samples.

Finally, the data samples have been checked for the presence of foreign securities trading via American Depository Receipts (ADRs). These securities were deleted from the sample to remove any currency translation effects which might affect parameter estimates. The resulting data samples has been exhaustively checked to assure a reasonably high degree of accuracy. This included spot checking of closing prices and ex-dividend dates reported in the **Wall Street Journal** for randomly selected days and stocks. The resulting data sample should permit accurate estimation of "true" returns and variances in a manner consistent with that suggested by Blume and Stambaugh (1983), Glosten and Milgrom (1985), and the extensive literature on the EMH.

4.3 Measurement of Variables

The methods used to measure portfolio returns in testing low price effects follow Roll (1983). Accordingly, mean portfolio returns are measured AR, BH, and RB. The January effect is tested using geometric returns computed for each security, then averaged cross-sectionally by quintile for the months of December and January. January returns assume that stocks were purchased on December 31st. This is in accord with the general convention adopted in this investigation; re-balancing to equal weights are assumed to occur on December 31st and are motivated by tax-related reasons. This differs from the usual practice of cross-sectional averaging of daily returns for the period under observation. The latter practice yields substantial distortions in the magnitude of reported anomalies. The general method in this investigation is to calculate geometric returns for individual securities and measure variances as the difference between the mean geometric return and the discrete period returns. This practice yields more appropriate estimates of the contribution of individual securities to portfolio variance. Elsewhere, individual daily returns are computed, summed, and averaged cross-sectionally by decile and for the overall sample. We expect no loss of generality from using this method.

As noted in the introduction and literature review, almost all prior studies on bid-ask spreads and their determinants were based on small samples of bid-ask data. Some samples were cross-sectionally large but none were time series large. No sample reported in the literature was deemed large enough to permit a reasonable subdivision into quartiles, quintiles, or deciles. The current study provides a total of 85 days of closing bid and ask price data for over two thousand securities. The data sample covers two pronounced market movements. The resulting contrast will enable us to make better descriptions of market behavior in the case of spreads, returns, and measurement errors.

4.4 The Degree of Bias in Computed Returns

We suggested earlier that biases are introduced when returns are measured using closing prices. A more realistic measurement of returns would assume the use of "market" orders (the only type that assures a trade). Most market orders to sell are executed at the bid while most market orders to buy are executed at the ask. Accordingly, returns should be measured from yesterday's ask for a buy to today's bid for a sell. Buying at the bid (in effect competing with the specialist) and selling at the ask is also possible. Returns based on such trades would assume the use of attractively placed "limit" orders for both the buy and the sell. This discussion suggests three alternative return measurement methods: Close-to-close, ask-to-bid, and bid-to-ask. This investigation will study returns measured ask-to-bid (Rab) and bid-to-ask (Rba) in addition to close-to-close (Rcc) returns. The magnitude of return measurement biases for the data samples will be reported in chapter V in summary form. Mean daily returns variances are also examined to determine relative volatilities.

Average daily returns will be computed utilizing closing prices and compared to average daily returns computed from the mean of the closing bid and ask price quotes for each data sample. Additionally, each sample will be stratified by price and average returns computed for each decile. Three sets of returns will be computed: AR, BH, and RB following Roll (1983). The December 1, 1981 closing price will be utilized as the stratification variable. Any biases due the "bid-ask" effect will be demonstrated by a significant difference between returns measured close-to-close (CC) and returns measured with the daily means of the closing bid and ask price quotes (MAB). Thus, six sets of returns are computed and corresponding sets, three for each sub-sample, tested for the statistical significance of the differences (CC-MAB) for each of the Roll (1983) portfolio return measurement models.

4.5 Testing Empirical Anomalies

The limited time horizon of the data samples utilized in this study requires that the samples be tested for the presence of previously reported anomalies. The presence of these anomalies when returns are measured in the traditional way (close-to-close) will serve to underscore the validity of any different results obtained when the alternative return generating specifications are used. Accordingly, the data samples will be divided into deciles using closing prices on December 1st as the stratification variable. Statistical testing of the data samples should reveal the presence of significant weekend and low price effects previously reported by French (1980) and Stoll and Whaley (1983), respectively.

The price-stratified samples will be utilized to measure mean December and January returns for buy-hold portfolios. Student-t tests for the difference between January and December mean daily returns should indicate if January returns are significantly less negative or more positive compared to December for the low price decile. Also, these results may be influenced by the presence of a January effect.

Statistical tests for the significance of the difference between two means will be conducted to verify the presence of the weekend effect in the data sample. The t-statistic for all stocks in each sample is expected to indicate a significant weekend effect. The results of these tests may be affected by the time period covered by the data samples. The weekend effect examined during a period at the turn-of-the-year may be different from the weekend effect examined at other times of the year. The first day of January has been reported by Keim (1983) and others to contain the largest proportion of the size affect. Both data samples in this study commence the new year on a Monday. Therefore, testing will be conducted with the new years' returns included and excluded from the samples.

Friday-Monday returns have been reported to be significantly (more) negative than Monday-Tuesday returns. The same test will be repeated for each of the price-stratified deciles. These tests should provide additional insights into the nature of the weekend returns anomaly. Also, the price stratified deciles will be dichotomized on the basis of stocks declaring dividends during the sample time frame and those which did not declare dividends. The strong presence of a weekend effect when prices are corrected for dividends indicates the effect is not an artifact of a systematic trend for large numbers of stocks to go ex-dividend on Mondays. This result will be strengthened if non-ex-dividend stocks also experience negative weekend returns in contrast to (positive) weekday returns.

The tests will be repeated using returns measured ask-to-bid and bid-to-ask to test for persistence of the effect. If the effects are still present we can tentatively conclude that the empirical anomalies are not statistical artifacts resulting from the manner in which returns are measured. Alternatively, if the effects are not present when returns are measured using alternative specifications of the return generating process, we may tentatively conclude that the empirical anomalies are artifacts of the manner in which returns have been traditionally measured.

CHAPTER 5

RESULTS I

5.1 Sample Summary Statistics

A meaningful evaluation of the empirical results to be reported in chapter VI requires an understanding of the biases induced in returns when those returns are computed solely with closing prices. The key to that knowledge is an understanding of the behavior of prices, bid-ask spreads, trading volumes, and trading activity at the microstructure level. The chapter begins with an examination of the distributions and changes in the magnitude of the relevant variables. The test sample statistics are reported first. The same information is then reported for the verification sample. Differences are noted along with potential explanations. The expected result is an increase in our understanding of market microstructure behavior and new insight on the nature of empirical anomalies in the research literature.

The hypotheses to be examined in this study are first tested using test sample one (TS1). These results are then compared to a second sample, test sample two (TS2). The data are analyzed under two general schemes; collectively, and stratified by price (closing price on December 1, 1981 or December 1, 1982). Securities are assigned to ten equal-weighted portfolios and daily cross-sectional average returns calculated for each price-stratified portfolio. These portfolios were maintained for all subsequent calculations, in effect creating buy-and-hold portfolios.

Figure 5.1.A displays the trend of the daily cross-sectional average price for TS1. (Chart Note: F = Friday, T = Thursday)

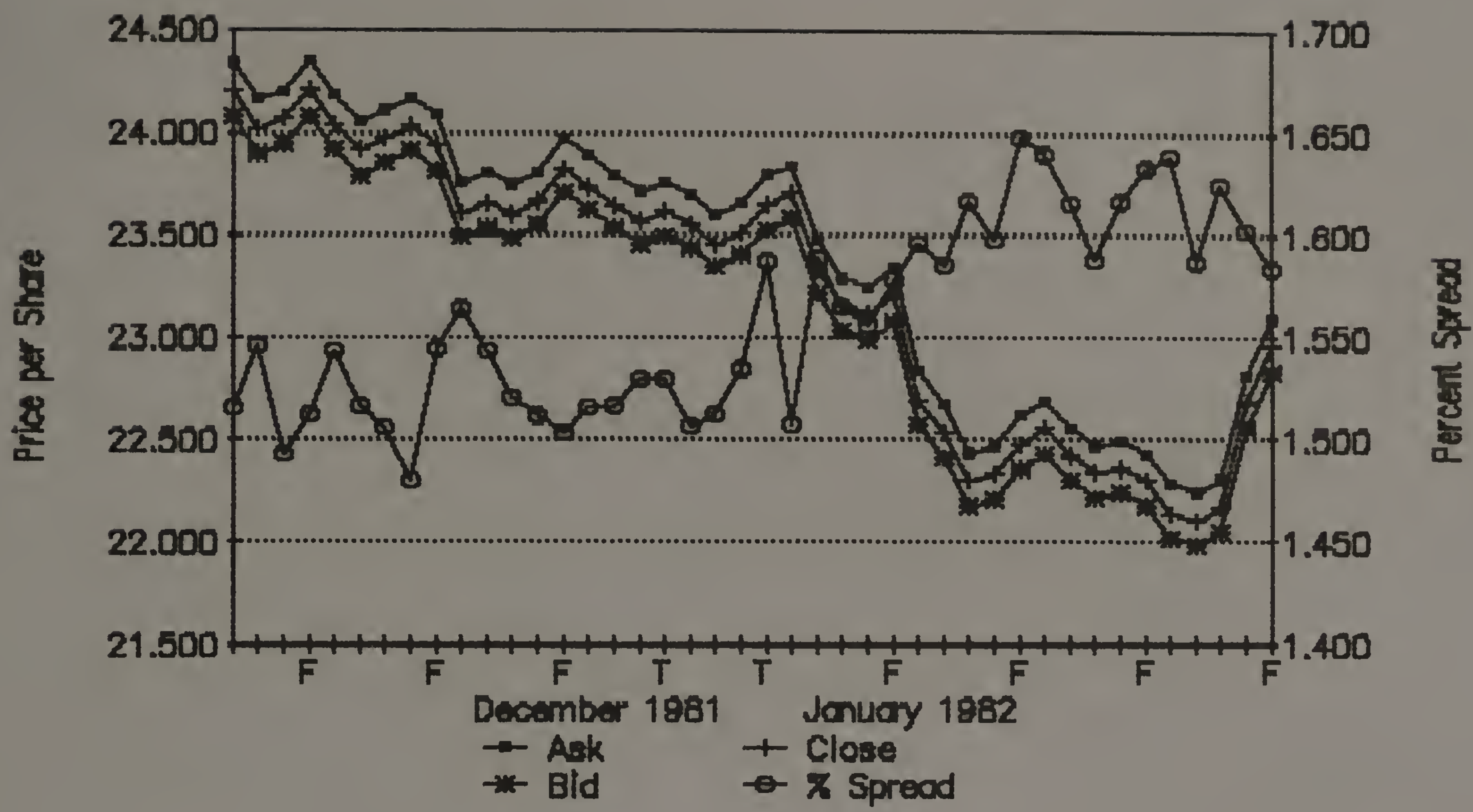

Figure 5.1.A. Closing Bid, Asked, and Last Trade Prices. Daily cross-sectional averages for 1134 NYSE issues in test sample one for period December 1, 1981 through January 29, 1982.

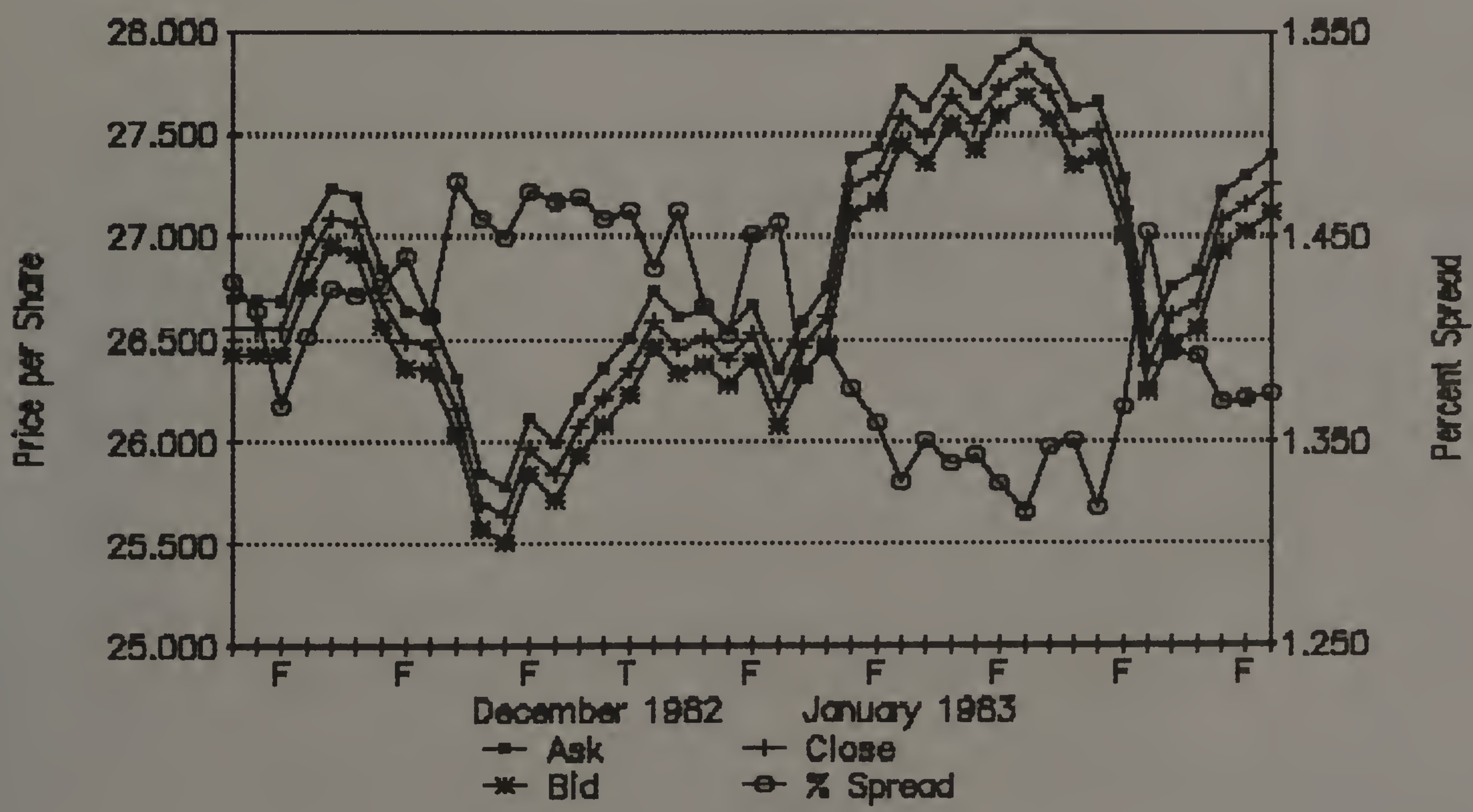

Figure 5.1.B. Closing Bid, Asked, and Last Trade Prices. Daily cross-sectional averages for 1205 NYSE issues in test sample one for period December 1, 1982 through January 31, 1982.

Prices in TS1 declined slowly throughout December (1981). The rate of decline accelerated the first seven trading days in January (1982). Figure 5.1.B (p. 68) displays the average price trends in TS2. The broad market finished approximately where it started for the month of December; the January market finished noticeably higher.

Table 5.1.A (p. 70) presents summary data for each decile in TS1. January prices were typically lower in all deciles compared to December reflecting the general bear trend of the market during this time frame. Relative (percentage) spreads were larger in January for all deciles: The increase in January relative spreads reflects lower prices and a general decline in share volume. The behavior of the average relative spread for TS1 is plotted in figure 5.1.A. These results are in conformance with the behavior of spreads reported by Demsetz, et al. Column (4) contains the average daily value of the absolute (dollar) spread for all stocks in each decile; absolute spreads increase as stock prices get larger. Demsetz (1968) suggested that the absolute spread increases with share price in order to maintain constant proportionality between the cost of transacting and total transaction dollar value. Column (5) contains the average relative spread: Relative spreads are largest for the lowest-priced stocks and exhibit a monotone decline by decile as prices get larger. These results accord with those reported by Demsetz (1968), Tinic (1971), and others researching microstructure behavior. Moreover, the results indicate that the general characteristics of test sample one are similar to those reported by other researchers using different (and smaller) samples of bid-ask price data and different time frames. Accordingly, we conclude that TS1 is typical of securities traded on the NYSE.

Table 5.1.A: Average Daily Closing Prices & Spreads
Test Sample One Summary Data by Deciles

DECEMBER 1981

Dec	(1) Close	(2) Bid	(3) Ask	(4) $Sprd	(5) %Sprd	(6) N
1	4.978	4.910	5.082	0.172	4.002	105
2	9.940	9.857	10.061	0.204	2.081	113
3	13.226	13.123	13.357	0.234	1.781	112
4	16.076	15.969	16.216	0.247	1.546	106
5	18.934	18.818	19.077	0.260	1.372	121
6	22.672	22.546	22.825	0.278	1.235	114
7	26.069	25.936	26.225	0.288	1.111	100
8	30.198	30.061	30.356	0.295	0.982	121
9	36.686	36.540	36.844	0.303	0.831	114
10	53.405	53.248	53.572	0.323	0.615	128

JANUARY 1982

Dec	(1) Close	(2) Bid	(3) Ask	(4) $Sprd	(5) %Sprd	(6) N
1	4.898	4.815	4.990	0.175	4.159	105
2	9.741	9.643	9.852	0.210	2.204	113
3	12.857	12.744	12.984	0.241	1.891	112
4	15.656	15.542	15.789	0.247	1.596	106
5	18.311	18.186	18.449	0.263	1.440	121
6	21.486	21.354	21.634	0.281	1.317	114
7	24.803	24.666	24.957	0.290	1.178	100
8	28.807	28.671	28.957	0.286	1.004	121
9	34.024	33.879	34.177	0.297	0.882	114
10	50.441	50.287	50.601	0.314	0.639	128

Note: %Sprd = (ask-bid)/((ask+bid)/2) * 100

Table 5.1.B (p. 71) displays the summary data for each decile in TS2. In TS2, prices are typically higher in January compared to December. Percentage spreads are typically smaller in January; a result of slightly higher prices. December and January absolute spreads are insignificantly different. General comparisons of TS1 and TS2 reveal a consistent orderliness in the behavior of spreads in response to changes in price levels. Percentage spreads tend to get larger as prices get smaller and vice-versa. This behavior is shown in figures 5.1.A and 5.1.B.

Table 5.1.B: Average Daily Closing Prices & Spreads
Test Sample Two Summary Data by Decile

DECEMBER 1982

Dec	(1) Close	(2) Bid	(3) Ask	(4) \$Sprd	(5) %Sprd	(6) N
1	5.685	5.608	5.789	0.181	3.729	109
2	10.640	10.547	10.763	0.216	2.058	110
3	15.029	14.915	15.159	0.243	1.639	145
4	17.960	17.845	18.105	0.260	1.455	100
5	20.885	20.767	21.034	0.267	1.288	130
6	24.716	24.594	24.878	0.283	1.151	132
7	28.616	28.500	28.797	0.297	1.042	118
8	33.832	33.693	33.998	0.306	0.909	118
9	42.070	41.916	42.236	0.320	0.768	124
10	62.917	62.738	63.105	0.368	0.598	119

JANUARY 1983

Dec	(1) Close	(2) Bid	(3) Ask	(4) \$Sprd	(5) %Sprd	(6) N
1	6.364	6.271	6.455	0.184	3.475	109
2	11.501	11.395	11.609	0.214	1.909	110
3	15.927	15.813	16.054	0.242	1.539	145
4	19.051	18.923	19.183	0.261	1.385	100
5	21.970	21.840	22.109	0.269	1.242	130
6	25.378	25.259	25.538	0.280	1.114	132
7	29.676	29.550	29.841	0.291	0.991	118
8	34.830	34.703	35.011	0.309	0.904	118
9	42.589	42.437	42.751	0.314	0.750	124
10	62.831	62.649	63.022	0.374	0.610	119

Note: %Sprd = (Ask-Bid)/((ask+bid)/2) * 100

In general, prices (average decile) in TS2 are uniformly greater than prices in TS1. The equally weighted average prices in TS1 and TS2 are \$23.226 and \$26.786, respectively. Also, TS1 dollar spreads are greater and percentage spreads smaller compared to TS1.

5.2 Bid-Ask Spread Behavior

Earlier we have suggested that increases in absolute spreads and decreases in relative spreads are log-linear functions of price. We observe in figure 2.1 (chapter 2), however, that the relative spread in the lowest price decile does not appear to be a strictly linear function of price (Figure 2.1 is plotted using sample averages from table 5.1.A). This observation is tested using linear regression and a logarithmic transformation of the data in table 5.1.A. We note that regressions on decile data are very low power compared with regression analysis on the actual spreads for all stocks in the data samples. The following analysis is performed to estimate the degree to which actual bid-ask spreads deviate from those predicted by a linear regression model.

Two regressions are estimated and the error processes examined. The first regression included price and relative spread data for deciles 2 through 10. The regression parameter estimates were used to estimate the relative spread for the first decile given the average price for stocks in that decile. The relative spread estimate for decile 1 is 2.896 standard errors from the regression line; the fitted regression line under-estimates the actual spread. The second regression included price and relative spread for all ten deciles. The result is a decrease in the forecast error for the first decile (1.152 standard errors from the regression line) and an increase in forecast error for the second decile (-2.080 standard errors); spreads are under-estimated for the lowest price decile and substantially over-estimated for the second price decile. We concluded that relative spreads for the lowest price decile tend to exceed the proportionality implied by Demsetz (1968) by a significant amount. Moreover, including the lowest price decile in the regression increases the standard error of the forecast. This result may be due in part to the 1/8 point minimum spread used on the NYSE for all stocks trading in excess of one dollar per share. Smaller spreads might permit more nearly proportional bid-ask spreads when very low price levels are considered. The larger than expected relative spread for the lowest price stocks may be a significant factor in size effect or in low price effect studies.

Stocks in the tenth decile are characterized by the largest absolute ($) spreads (3/8 of a point on average). Stocks in the lowest price decile typically have low absolute spreads; slightly greater than 1/8 point on average. A related observation is that low prices increase the probability of specialist participation in market-order trading activity due to the size of the spread.

Trading volumes are not reported in detail for either of the two sub-samples in this study. They are available for TS1 but not for TS2. NYSE volumes were, however, substantially higher during the time period covered by TS2. Accordingly, we make the assumption that trading volumes were higher in all price deciles. The general support for this assumption is the difference in average bid-ask spreads between the two samples. TS2 spreads were typically lower than TS1 spreads. This difference is due in part to slightly higher prices and higher trading volumes.

5.3 Computing Returns Under Alternative Assumptions

Average daily returns are computed using three alternative methods: ask_{t-1}-to-bid_t, bid_{t-1}-to-ask_t, and $close_{t-1}$-to-$close_t$. Returns measured ask-to-bid assume the use of market orders for one round lot; buy at the ask and sell at the bid. Since market orders require immediate execution, they are almost certain to be executed without difficulty. Returns measured bid-to-ask assume the use of limit orders; buy at the bid and sell at the ask. This bid-ask return represents a "best case" assumption for a trader. The execution of a limit order placed to buy at the bid or sell at the ask is relatively uncertain. Not only must a trader emerge to take the other side, but such trading interest must be sufficiently large to absorb any orders that had been previously placed at the limit price. Clearly, a trading strategy which assumes the use of market orders (the worst case assumption) is much more realistic than one which assumes trades at either the close or at favorably placed limit orders, particularly for infrequently traded stocks. For stocks with high trading volumes, measuring returns bid (buy) to ask (sell) is more likely but still unrealistic. For comparative purposes returns are also measured using closing prices. The three sets of calculated returns exhibit considerable differences. Table 5.2.A (TS1) and Table 5.2.B (TS2) show the (unweighted) average daily cross-sectional returns and the average difference between alternative return measures for all stocks in each sample. Columns (1), (2), and (3) in both tables indicate the mean daily return for all stocks in each sample. Returns are measured $close_{t-1}$-to-$close_t$ (CC), ask_{t-1}-to-bid_t (AB), and bid_{t-1}-to-ask_t (BA), and are computed using equation (5.1)

$$r_t = [(p_t + d_t) / p_{t-1}] - 1 \qquad (5.1)$$

where: r_t = holding period return
p_t = closing price quote (ask, bid, or close)
p_{t-1} = closing price quote (ask, bid, or close)
d_t = dividend paid to owners of record day t
where t = last cum dividend trade date

The unweighted average daily (CC) return for all stocks in TS1 for the 42-day period was -.0896% , a value insignificantly different from zero. The average (AB) and (BA) returns were -1.633% and 1.484%, respectively. (AB) and (BA) returns are significantly different from zero at the .01 level. The corresponding values for TS2 (43 days) are .160% (CC), -1.228% (AB), and 1.585% (BA); (CC) returns are insignificantly different from zero, (AB) and (BA) are both significant at the .01 level. Also, returns measured (AB) and (BA) are significantly different from returns measured (CC) at the .01 level.

We test the significance of the differences between the two sets of sample summary data averages contained in tables 5.2.A (p.76) and 5.2.B (p. 77) to determine if the two samples from the same population. Testing the differences between corresponding TS1 and TS2 mean daily returns yielded the following; (CC) and (BA) returns are insignificantly different at the .05 level (t = 1.363 and 0.555 respectively). (AB) returns are significantly different at the .01 level (t = 2.276).

Column (4) demonstrates the daily average magnitude of the return measurement bias between returns measured close-to-close and returns based on market order executions for buying and selling (CC-AB). The average magnitude of the difference is 1.544% for TS1 (Table 5.2.A) and 1.388% for TS2 (Table 5.2.B). These results indicate that a bias is induced in returns when closing prices are utilized instead of bid and ask prices. As previously noted, the latter represent prices more likely to be obtained by public traders using market orders.

Column (5) demonstrates the average of the return measurement bias when limit order executions are assumed. The average magnitudes of the bias are -1.574% for TS1 and -1.425% for TS2. Column (6) shows the magnitude of the difference (BA-AB) between market order returns and

Table 5.2.A: Average Daily Returns and Differentials
Test Sample One: 1134 NYSE Issues

Day	(1) CC	(2) AB	(3) BA	(4) CC-AB	(5) CC-BA	(6) BA-AB
2	-0.662	-2.117	0.931	1.455	-1.594	3.049
3	0.207	-1.358	1.681	1.565	-1.474	3.039
4	0.624	-0.860	2.163	1.483	-1.539	3.022
5	-0.746	-2.206	0.828	1.459	-1.574	3.033
6	-0.618	-2.156	0.876	1.538	-1.495	3.033
7	0.159	-1.315	1.708	1.474	-1.549	3.023
8	0.197	-1.293	1.698	1.490	-1.501	2.991
9	-0.297	-1.784	1.236	1.487	-1.533	3.020
10	-1.384	-2.851	0.214	1.467	-1.598	3.065
11	0.293	-1.281	1.837	1.574	-1.544	3.118
12	-0.247	-1.722	1.335	1.474	-1.582	3.057
13	0.185	-1.336	1.696	1.521	-1.512	3.032
14	0.677	-0.829	2.208	1.506	-1.531	3.037
15	-0.412	-1.847	1.164	1.434	-1.576	3.010
16	-0.263	-1.781	1.246	1.518	-1.509	3.027
17	-0.201	-1.718	1.325	1.517	-1.526	3.043
18	0.378	-1.195	1.879	1.573	-1.501	3.075
19	-0.396	-1.816	1.205	1.420	-1.601	3.021
20	-0.386	-1.890	1.118	1.503	-1.504	3.008
21	0.351	-1.183	1.879	1.533	-1.528	3.061
22	0.739	-0.859	2.293	1.598	-1.554	3.152
23	0.598	-1.022	2.104	1.620	-1.506	3.126
24	-1.328	-2.837	0.229	1.508	-1.557	3.065
25	-0.685	-2.259	0.875	1.574	-1.561	3.134
26	-0.065	-1.605	1.521	1.540	-1.586	3.126
27	0.457	-1.097	2.053	1.555	-1.596	3.151
28	-2.083	-3.555	-0.440	1.473	-1.643	3.115
29	-0.706	-2.266	0.891	1.560	-1.597	3.157
30	-0.989	-2.566	0.606	1.577	-1.596	3.173
31	0.165	-1.471	1.744	1.636	-1.579	3.215
32	0.597	-1.005	2.259	1.602	-1.662	3.264
33	0.289	-1.378	1.907	1.668	-1.618	3.285
34	-0.530	-2.080	1.176	1.551	-1.705	3.256
35	-0.281	-1.871	1.327	1.590	-1.608	3.198
36	0.107	-1.483	1.724	1.590	-1.617	3.207
37	-0.288	-1.874	1.369	1.585	-1.657	3.242
38	-0.869	-2.435	0.800	1.567	-1.669	3.235
39	-0.071	-1.706	1.514	1.635	-1.585	3.220
40	0.310	-1.262	1.962	1.572	-1.652	3.224
41	2.300	0.561	3.858	1.739	-1.559	3.298
42	1.206	-0.366	2.860	1.571	-1.654	3.226
Mean	-0.896	-1.633	1.484	1.544	-1.574	3.188

Notes for Tables 5.2A and 5.2B

1. CC = Returns measured close-to-close
2. AB = Returns measured Ask-to-Bid (market order)
3. BA = Returns measured Bid-to-Ask (limit order)
4. CC-AB , CC-BA, BA-AB = Return Differentials

Table 5.2.B: Average Daily Returns and Differentials
Test Sample Two: 1204 NYSE Issues

Day	(1) CC	(2) AB	(3) BA	(4) CC-AB	(5) CC-BA	(6) BA-AB
2	-0.091	-1.519	1.314	1.428	-1.405	2.833
3	-0.055	-1.420	1.358	1.365	-1.413	2.777
4	1.091	-0.328	2.468	1.419	-1.377	2.796
5	0.691	-0.674	2.170	1.365	-1.480	2.844
6	0.090	-1.336	1.520	1.426	-1.430	2.856
7	-0.854	-2.255	0.577	1.401	-1.431	2.832
8	-0.637	-1.944	0.909	1.307	-1.546	2.853
9	-0.030	-1.512	1.335	1.482	-1.365	2.847
10	-1.038	-2.403	0.461	1.365	-1.499	2.863
11	-1.634	-3.032	-0.139	1.398	-1.494	2.893
12	-0.271	-1.723	1.170	1.452	-1.441	2.893
13	1.177	-0.292	2.661	1.469	-1.484	2.952
14	-0.477	-1.932	0.990	1.455	-1.467	2.922
15	0.781	-0.693	2.264	1.474	-1.482	2.957
16	0.559	-0.797	2.149	1.357	-1.589	2.946
17	0.632	-0.867	2.079	1.499	-1.447	2.946
18	0.966	-0.471	2.454	1.437	-1.487	2.924
19	-0.406	-1.712	1.175	1.306	-1.582	2.888
20	0.202	-1.303	1.579	1.505	-1.377	2.881
21	-0.190	-1.585	1.234	1.396	-1.424	2.820
22	0.649	-0.757	2.125	1.405	-1.476	2.881
23	-0.824	-2.352	0.539	1.528	-1.363	2.891
24	1.240	-0.216	2.664	1.456	-1.424	2.880
25	0.829	-0.517	2.293	1.347	-1.464	2.811
26	2.546	1.101	3.947	1.445	-1.401	2.846
27	0.328	-0.967	1.783	1.295	-1.455	2.750
28	1.284	-0.049	2.680	1.333	-1.396	2.729
29	-0.237	-1.552	1.128	1.315	-1.365	2.680
30	0.765	-0.565	2.147	1.330	-1.382	2.712
31	-0.423	-1.752	0.922	1.329	-1.345	2.674
32	0.709	-0.654	2.040	1.363	-1.331	2.694
33	0.454	-0.794	1.865	1.248	-1.411	2.659
34	-0.221	-1.567	1.096	1.345	-1.318	2.663
35	-0.696	-2.016	0.671	1.320	-1.367	2.687
36	0.229	-1.077	1.602	1.306	-1.373	2.679
37	-1.208	-2.527	0.131	1.319	-1.338	2.657
38	-2.903	-4.174	-1.437	1.271	-1.466	2.737
39	1.097	-0.408	2.466	1.505	-1.370	2.875
40	0.320	-1.059	1.739	1.378	-1.420	2.798
41	1.383	-0.033	2.762	1.416	-1.379	2.795
42	0.313	-0.957	1.800	1.269	-1.487	2.756
43	0.571	-0.886	1.876	1.457	-1.305	2.762
Mean	0.160	-1.228	1.585	1.388	-1.425	2.813

(optimally placed) limit order returns. This return differential corresponds to the difference between executing limit orders under favorable conditions (buy at bid_{t-1} , sell at ask_t) and executing market orders under normal conditions (buy at ask_{t-1} , sell at bid_t). The average magnitude of the difference between the two trade-oriented returns is 3.118% for TS1 and 2.813% for TS2.

The magnitude of the bias stemming from the utilization of close-to-close returns is non-trivial. Indeed many reported anomalies are in the same 1% to 2% range of the return measurement bias. The overstatement of close-to-close returns relative to those that are realizable, coupled with nonlinearities in the relationships, may well have resulted in the many findings of abnormal returns. In section 5.3 we examine in greater detail the nature of the bias operating on different price stratifications. Of particular interest is the behavior of the percentage spread around the turn-of-the-year and the distribution of closing prices relative to the closing bid and ask price quotes.

5.4 Average Daily Returns for Price-Stratified Deciles

Average daily returns for each of the price-stratified deciles are measured utilizing the three trading price assumptions discussed in section 5.3. Table 5.3 (p. 80) displays information for each assumed type of trade's returns by decile by month; Panel A contains the results for TS1, Panel B for TS2. For decile 1, returns measured ask-to-bid (AB) are substantially lower than those measured close-to-close (CC). This result is due to measuring returns across the bid-ask spread assuming market order executions. The situation is reversed when returns are

Table 5.3: Stratified Mean Daily Returns
For Strategies: Ask-Bid, Bid-Ask, Close-Close

Panel A: Test Sample One

Dec	December 1981 CC	AB	BA	January 1982 C-C	A-B	B-A
1	-0.225	-4.119	3.858	-0.040	-4.107	4.229
2	-0.074	-2.129	2.028	-0.039	-2.218	2.184
3	-0.084	-1.838	1.714	-0.060	-1.938	1.835
4	-0.087	-1.609	1.474	-0.023	-1.619	1.575
5	-0.101	-1.462	1.281	-0.094	-1.525	1.349
6	-0.063	-1.284	1.182	-0.188	-1.496	1.129
7	-0.078	-1.182	1.037	-0.235	-1.402	0.945
8	-0.091	-1.068	0.895	-0.154	-1.150	0.854
9	-0.162	-0.984	0.673	-0.232	-1.114	0.648
10	-0.109	-0.722	0.507	-0.155	-0.792	0.484

Panel B: Test Sample Two

Dec	December 1982 CC	AB	BA	January 1983 C-C	A-B	B-A
1	0.019	-3.617	3.849	0.589	-2.871	4.136
2	0.051	-1.978	2.130	0.373	-1.542	2.300
3	0.092	-1.532	1.745	0.226	-1.310	1.784
4	0.072	-1.373	1.545	0.268	-1.113	1.664
5	0.065	-1.211	1.368	0.215	-1.025	1.461
6	-0.014	-1.155	1.144	0.160	-0.953	1.284
7	0.020	-1.019	1.067	0.175	-0.812	1.178
8	-0.009	-0.909	0.908	0.160	-0.746	1.072
9	-0.006	-0.772	0.766	0.087	-0.660	0.840
10	-0.057	-0.656	0.541	0.108	-0.500	0.718

measured bid-to-ask (BA) assuming limit order executions. This last method of computation yields positive returns for all deciles in both months, with returns in January being higher for the first five deciles. Returns measured CC were typically negative in TS1; typically positive in TS2. In neither sample were CC returns significantly different from zero. Returns measured ask-to-bid (AB) were typically negative in both samples for all deciles; returns measured (BA) were typically positive. The smaller magnitudes of TS2 (AB) and (BA) returns are due to smaller bid-ask spreads resulting from generally higher prices.

Returns measured bid-to-ask (BA) and ask-to-bid (AB) were each subtracted from returns measured close-to-close (CC) and the results presented in table 5.4. Results for bid-to-ask returns minus ask-to-bid returns (BA-AB) are also displayed. The data indicate a substantial difference in return streams when measured either ask-to-bid or bid-to-ask relative to close-to-close; differences are approximately 4% per day for the lowest price decile. The values reported in table 5.4 indicate the average magnitude of the bias induced in measured returns computed using bid-ask quotes rather than closing price quotes. The mean differences between alternative

Table 5.4: Mean Daily Return Differentials
Close-AskBid, Close-BidAsk, BidAsk-AskBid

Panel A: Test Sample One

	December 1981			January 1982		
Dec	CC-AB	CC-BA	BA-AB	CC-AB	CC-BA	BA-AB
1	3.894	-4.083	7.977	4.067	-4.269	8.336
2	2.055	-2.102	4.157	2.179	-2.223	4.402
3	1.754	-1.799	3.552	1.878	-1.895	3.774
4	1.522	-1.561	3.083	1.596	-1.598	3.193
5	1.362	-1.382	2.744	1.431	-1.443	2.874
6	1.221	-1.244	2.465	1.307	-1.318	2.625
7	1.104	-1.115	2.219	1.167	-1.180	2.346
8	0.976	-0.986	1.963	0.996	-1.008	2.004
9	0.822	-0.835	1.657	0.882	-0.879	1.762
10	0.613	-0.616	1.228	0.637	-0.639	1.276

Panel B: Test Sample Two

	December 1982			January 1983		
Dec	CC-AB	CC-BA	BA-AB	CC-AB	CC-BA	BA-AB
1	3.636	-3.830	7.467	3.461	-3.547	7.008
2	2.029	-2.079	4.108	1.915	-1.926	3.841
3	1.624	-1.653	3.276	1.536	-1.558	3.094
4	1.445	-1.473	2.918	1.381	-1.395	2.776
5	1.276	-1.303	2.579	1.241	-1.245	2.486
6	1.141	-1.158	2.299	1.113	-1.124	2.238
7	1.039	-1.047	2.086	0.987	-1.003	1.991
8	0.900	-0.917	1.817	0.906	-0.912	1.818
9	0.766	-0.772	1.538	0.747	-0.753	1.500
10	0.598	-0.598	1.197	0.607	-0.611	1.218

measurement schemes were statistically significant at any usual level. Differences between alternative measures of return are largest for the lowest price decile and decline monotonically as stock price increases. These results are consistent with those reported earlier in this chapter. The difference between returns measured bid-to-ask and ask-to-bid averages approximately 8 % for the lowest price decile and 1.25% for the highest price decile. The differences are larger in January 1982 than in December 1981 for TS1 and are statistically significant at the .01 level for all deciles. January 1983 (BA-AB) values are smaller than December 1982 values for TS2; a result of smaller bid-ask spreads. The results presented here indicate that close-to-close returns are significantly overstated relative to what might actually be realized by an investor using market orders to execute trades. The degree of bias is strongly correlated with price level and bid-ask spread magnitudes. Also, the magnitude of the bias declines as per share prices get higher: The bias is greatest in the lowest price decile. Finally, we observe that many of the reported anomalies rely disproportionately on the performance of low price stocks.

5.5. Weekly and Monthly Holding Period Characteristics

The same portfolios described in the previous sections are used to compute mean weekly and monthly holding period return differentials for the three alternative computation methods. Weekly returns are measured from the last trading day of the preceding week, period (t-1), and the last trading day of the current week, period (t). Table 5.5 (p. 82) displays the results for this series of return differentials.

Table 5.5: Mean Weekly Return Differentials
Close-AskBid, Close-BidAsk, BidAsk-AskBid

Panel A: Test Sample One

	December 1981			January 1982		
Dec	CC-AB	CC-BA	BA-AB	CC-AB	CC-BA	BA-AB
1	3.834	-4.032	7.866	4.157	-4.341	8.498
2	2.077	-2.113	4.190	2.137	-2.146	4.284
3	1.709	-1.764	3.473	1.943	-1.881	3.824
4	1.517	-1.617	3.134	1.662	-1.566	3.228
5	1.378	-1.422	2.801	1.474	-1.449	2.923
6	1.200	-1.242	2.441	1.305	-1.283	2.588
7	1.117	-1.126	2.243	1.173	-1.180	2.353
8	0.986	-0.976	1.961	0.989	-1.005	1.994
9	0.809	-0.849	1.659	0.890	-0.843	1.733
10	0.618	-0.634	1.252	0.634	-0.629	1.263

Panel B: Test Sample Two

	December 1982			January 1983		
Dec	CC-AB	CC-BA	BA-AB	CC-AB	CC-BA	BA-AB
1	3.636	-3.897	7.534	3.671	-3.614	7.285
2	1.997	-2.095	4.092	2.006	-1.930	3.935
3	1.633	-1.745	3.378	1.564	-1.566	3.130
4	1.465	-1.453	2.917	1.361	-1.373	2.734
5	1.262	-1.325	2.587	1.241	-1.227	2.468
6	1.141	-1.160	2.301	1.132	-1.127	2.259
7	1.046	-1.043	2.089	0.981	-0.985	1.966
8	0.922	-0.957	1.878	0.856	-0.859	1.715
9	0.760	-0.766	1.527	0.729	-0.753	1.482
10	0.597	-0.579	1.176	0.596	-0.615	1.211

Similar to the results reported in section 5.3, weekly holding period returns measured ask-to-bid are lower than returns measured close-to-close. Returns measured bid-to-ask are substantially higher. All differences are statistically significant at the .01 level. The smaller magnitudes of all values reported in TS1 compared to those in TS2 reflect the smaller bid-ask percentage spreads in TS2. The smaller magnitude of the percentage spread is the result of higher prices in TS2.

Similar results are obtained for monthly holding period return differentials. Table 5.6 displays the pattern of monthly holding period return differentials as measured using the three different assumed trading patterns.

Table 5.6: Mean Monthly Return Differentials
Close-AskBid, Close-BidAsk, BidAsk-AskBid

Panel A: Test Sample One

	December 1981			January 1982		
Dec	CC-AB	CC-BA	BA-AB	CC-AB	CC-BA	BA-AB
1	3.899	-3.952	7.851	4.063	-4.158	8.221
2	2.034	-2.067	4.101	2.169	-2.043	4.211
3	1.687	-1.939	3.626	2.051	-1.682	3.733
4	1.441	-1.736	3.177	1.825	-1.356	3.181
5	1.306	-1.344	2.650	1.459	-1.298	2.757
6	1.159	-1.316	2.475	1.314	-1.164	2.478
7	1.119	-1.082	2.201	1.117	-1.101	2.218
8	0.955	-0.953	1.908	0.967	-0.996	1.963
9	0.777	-0.881	1.658	0.940	-0.732	1.672
10	0.603	-0.589	1.192	0.620	-0.583	1.204

Panel B: Test Sample Two

	December 1982			January 1983		
Dec	CC-AB	CC-BA	BA-AB	CC-AB	CC-BA	BA-AB
1	3.695	-4.266	7.961	4.848	-3.239	8.087
2	2.498	-2.668	5.166	2.611	-1.933	4.544
3	1.991	-2.100	4.091	1.841	-1.772	3.613
4	1.459	-1.661	3.120	1.680	-1.516	3.196
5	1.395	-1.635	3.030	1.511	-1.250	2.762
6	1.265	-1.430	2.694	1.200	-1.148	2.348
7	1.228	-1.158	2.386	1.000	-1.130	2.130
8	0.882	-1.073	1.955	0.980	-0.910	1.889
9	0.816	-0.830	1.646	0.771	-0.765	1.537
10	0.650	-0.573	1.222	0.621	-0.613	1.235

Comparisons of tables 5.4, 5.5, and 5.6 reveal similar monotone declines in return differentials as prices increase. Also, weekly and monthly holding period return differentials are typically smaller in December than January for most deciles. Returns measured bid-to-ask are substantially higher in January for the first four deciles. These findings are similar to the daily holding period results shown in table 5.4. Caution is warranted in intrepeting these results. Other samples may yield slightly different magnitudes.

The results reported in sections 5.3 and 5.4 indicate that returns measured ask-to-bid (AB), reflecting market order executions, and bid-to-ask (AB), reflecting limit order executions, are more sensitive to price levels than returns measured close-to-close (CC) when compared on a year to year basis. The source of this sensitivity is the behavior of the price-sensitive bid-ask spread. We tentatively conclude that measuring returns close-to-close introduces a bias in computed returns. Moreover, the bias is substantial for lower priced securities. The implication of these results is that the return generating process is misspecified if it does not consider the combined effects of bid-ask spreads and price levels. Also, returns measured utilizing closing prices do not adequately reflect the return most likely to be achieved by a trader after market microstructure behavior is appropriately factored into the process.

5.6. Turn-of-the-Year Closing Price Characteristics

The daily activity of closing prices relative to the closing bid and ask prices for TS1 are shown in figure 5.2.A (p. 85). The very small number of stocks with closes outside the bid-ask range are not shown. The chart reveals a fairly stable number of stocks closing at prices between the closing bid and ask quotes (the top line). The number of stocks closing at the bid or the ask is not as stable and also demonstrates evidence of a "weekend" effect in stock prices; a disproportionate number of Monday closes on the bid side is evidenced. Two exceptions to the "weekend" effect appear in figure 5.2.A. The first occurs January 4, the first trading day of the new year, which occurred on a Monday (the "M" following the second "T" from the left).

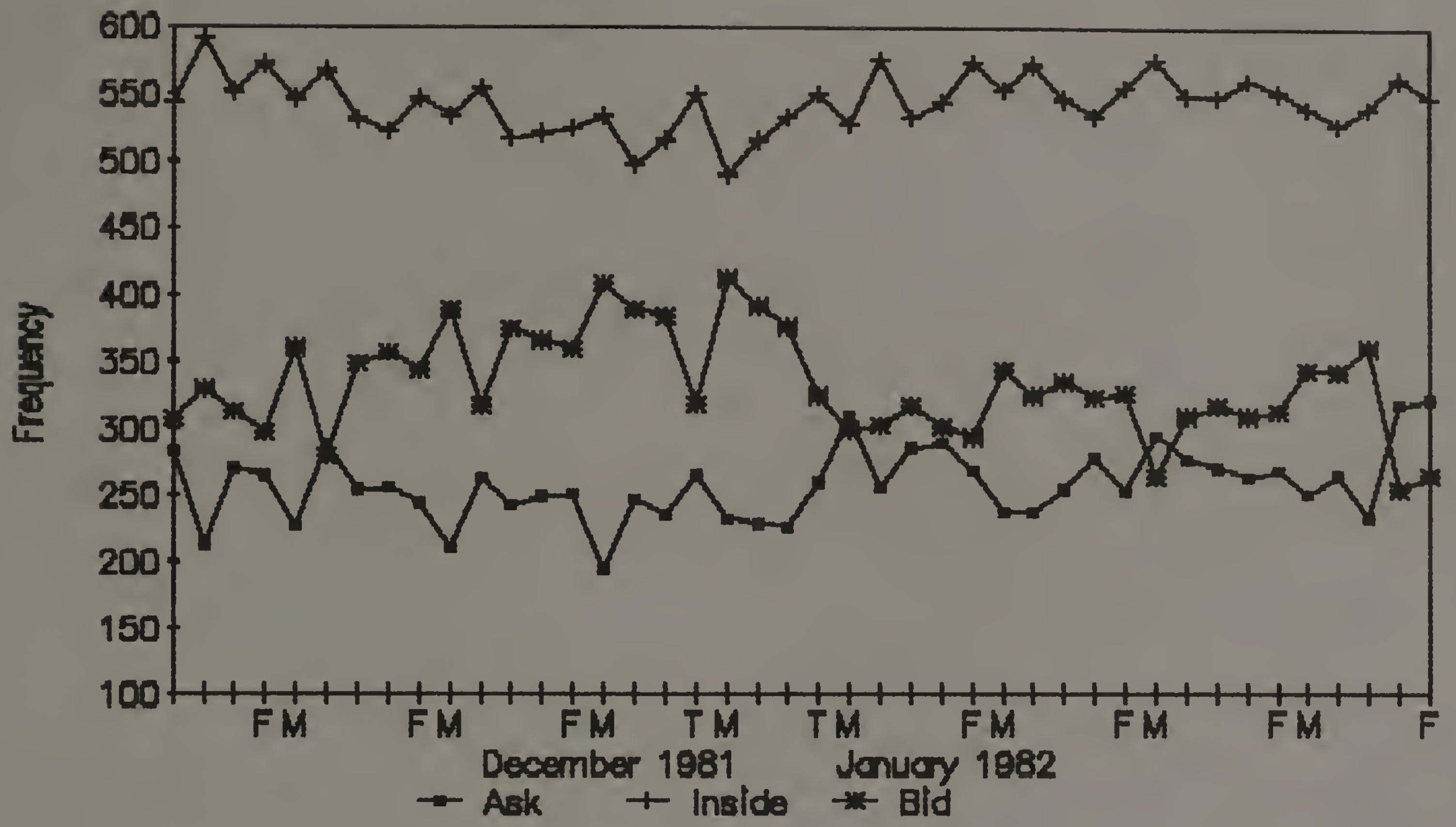

Figure 5.2.A. Daily last trade price distributions relative to closing bid and ask price quotations for TS1. TS1 year ended on Thursday (second "T" from left). M = Monday, F = Friday.

The frequency of ask side closes on January 4 are slightly greater than closes on the bid side. This finding supports Roll's (1983a) conjecture that part of the turn-of-the-year effect is caused by a shift in closing prices from the bid to the ask side. The second exception occurs on the third Monday in January (January 18). The traces of closes on the bid or ask quotes cross on both of these Mondays and re-cross the following Tuesday. The traces cross again on January 28 reflecting a "bullish" move by the market the last two trading days in January.

A possible explanation for the January effect is also evident in figure 5.2.A. The traces of closes on the bid and ask sides are on average much closer in January than December; the number of closes on the ask side increase as the number of bid-side closes decrease. The strong downward trend of the market in early January shown earlier in figure 5.1.A is not reflected in the distribution of closing price quotes shown in figure 5.2.A. We would expect that a downward movement of the market would be accompanied by an increase in the number of bid-side closes. Instead, we observe a decrease in the number of bid-side closes. Thus, a portion of the January effect may be partly explained by a change in the relative distributions of closing price quotes at the bid and ask.

Similar results for TS2 are displayed in figure 5.2.B. The most significant difference is the narrowing of the distribution of closes

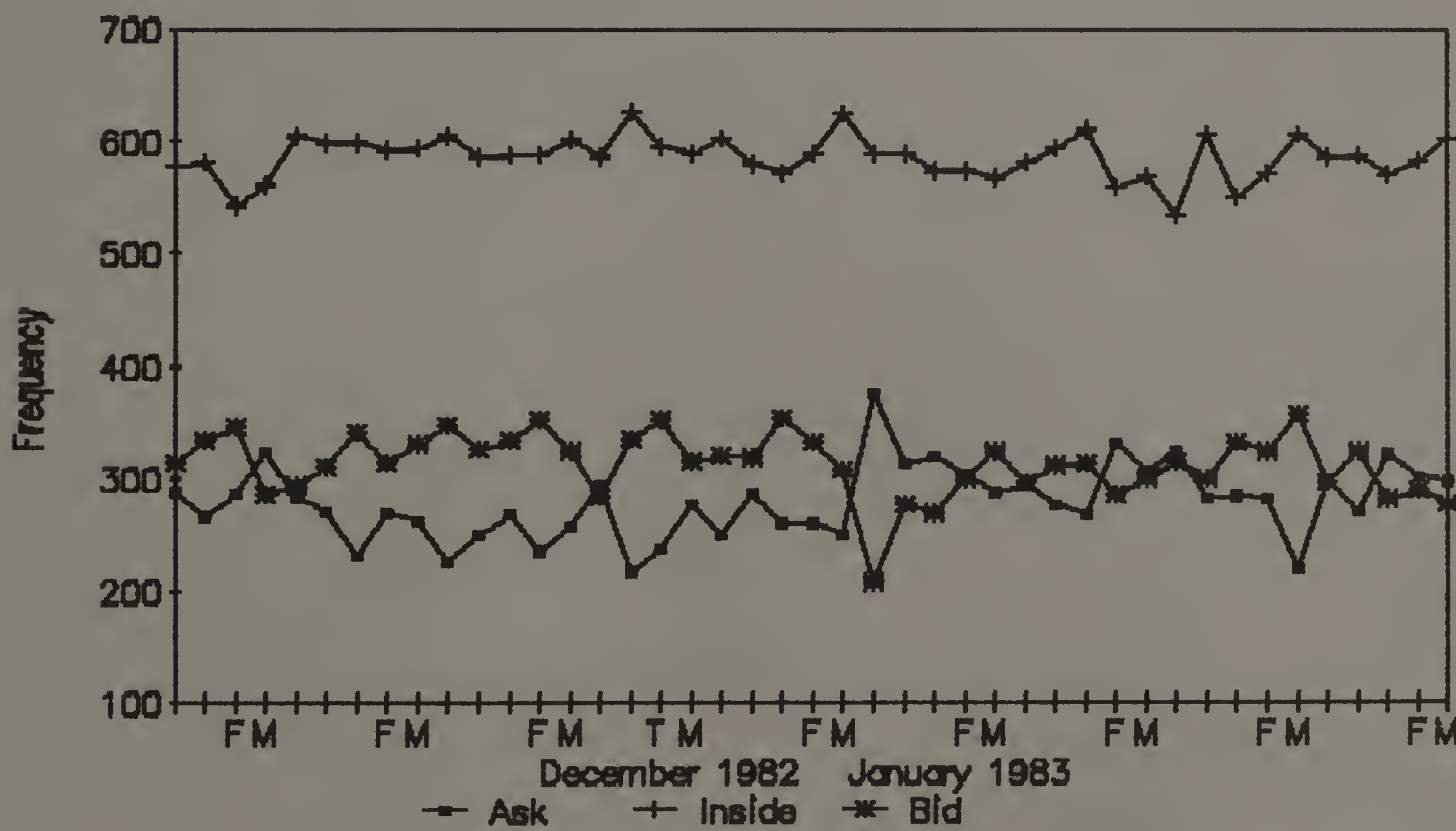

Figure 5.2.B. Daily last trade price distributions relative to closing bid and ask price quotations for TS2. TS2 year ended on Friday (first "F" following the "T"). M = Monday, T = Thursday.

on the bid-side and closes on the ask-side, especially after the first trading day in January. This reflects the bullish tendency of the market in TS2.

Figure 5.3.A is formed by displaying the daily values in figure 5.2.A as the average of the daily values for each week. The TS1 general trend is for bid-side closes to increase steadily throughout the month of December followed by a significant decline in the average number of bid-side closes during the first week in January. The December trend is also accompanied by declines in the number of closes on the ask-side as well as a small decline in the number of closes

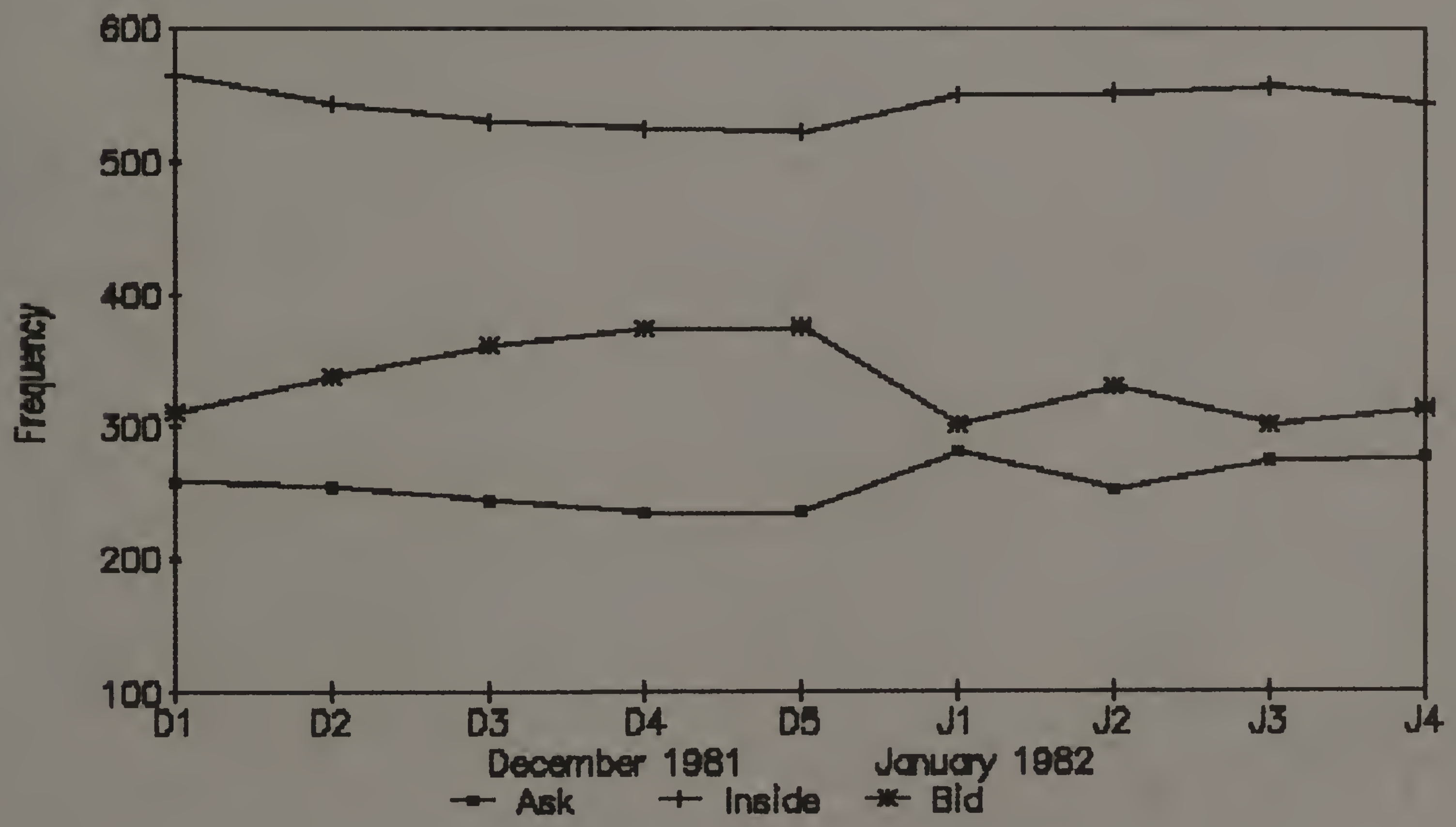

Figure 5.3.A. Weekly average last transaction price distributions for TS1. D1, D2,,,J4 denote the various weeks in December and January.

between the closing bid and ask quotes. The turn-of-the-year effect is (at least for 1981-82) fairly generalized cross-sectionally for the companies in the sample. More significant effects will be demonstrated when discrete price decile data are shown. The results for TS2 shown in figure 5.3.B are similar to those of TS1 in figure 5.3.A. TS2 shows a more significant change in the number of ask-side close during the first week in January. The general bullish tendency of the market in TS2 is accompanied by a narrow spread between bid and ask side closes.

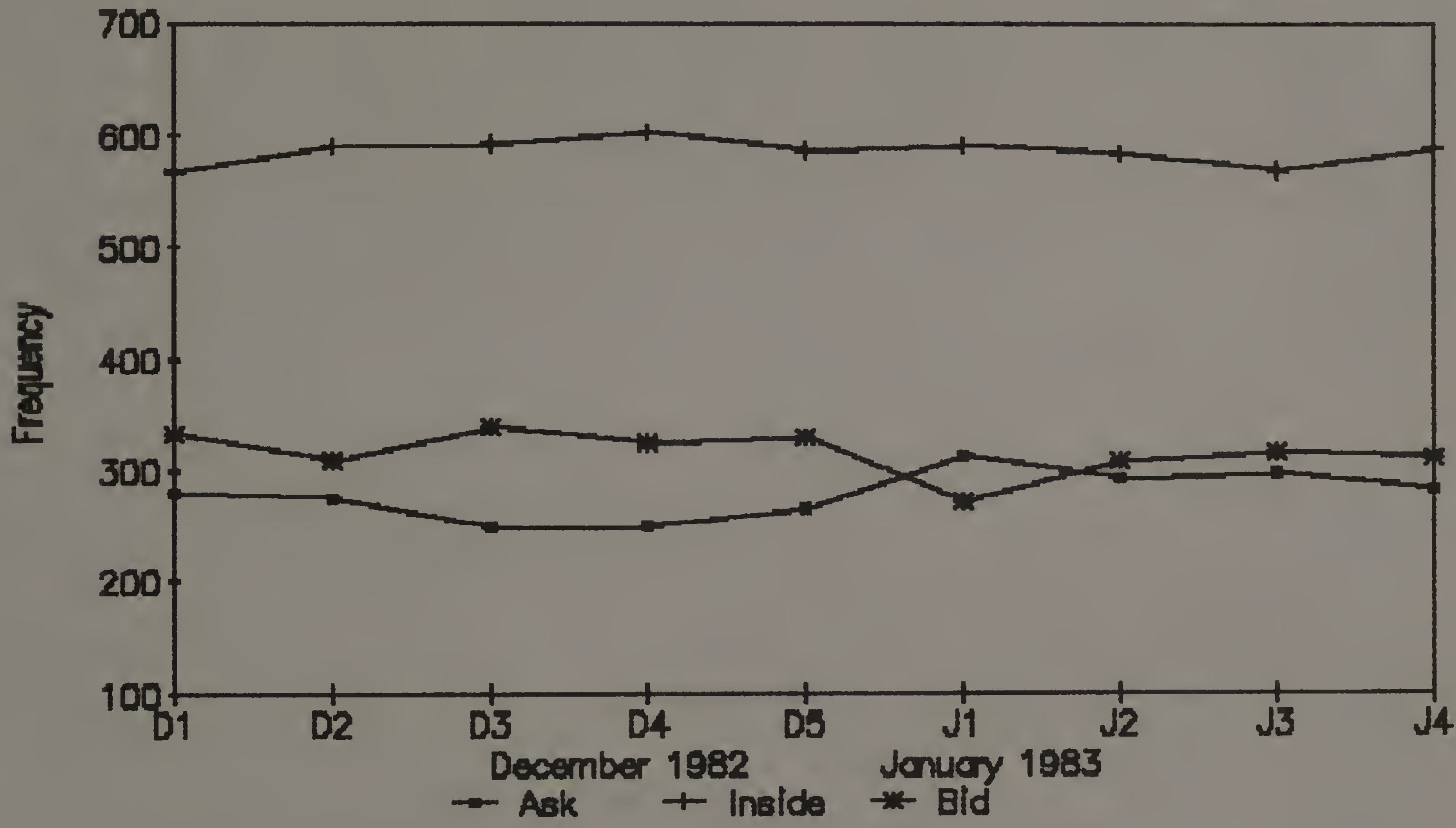

Figure 5.3.B. Weekly average last transaction price distributions for TS2. D1, D2,,,J4 denote the various weeks in December and January.

Lakonishok and Smidt (1983) constructed a "critical ratio" to illustrate the relationship of closing prices to the quoted high and low prices for the day. In a similar fashion we construct a Momentum Index (MI). The MI captures the average position of the last trade of the day relative to the closing bid and ask price quotes for all stocks in each sample. The variable is constructed to range from 0 to 1. A value of 0 indicates a close at the bid; a value of 1, a close at the ask. The MI is computed using equation (5.2):

$$MI = (C - B) / (A - B) \qquad (5.2)$$

where: MI = Momentum Index
C = Closing price (last trade of day)
A = Closing ask quote
B = Closing bid quote

Figures 5.4.A and 5.4.B (p. 90) show the mean value of this variable for each trading day for all stocks in TS1 and TS2, respectively. The MI exhibits a substantial amount of volatility for both samples. General trends emerge when averages are taken. Figures 5.5.A and 5.5.B (p. 91) display the daily values in figures 5.4.A and 5.4.B as weekly averages for TS1 and TS2, respectively. Throughout December the general trend of closing price-relatives is down indicating the effects of selling pressures on stock prices; potentially caused by year-end tax-selling or portfolio realignments. The downward trend stops at the second to last day in December and rises the first week in January. The trend lines in figures 5.5.A and 5.5.B clearly reflect closing prices momentum to the bid side during December and to the ask side in January. The trend reversal in the last trading week in December reflects the influence of the last trading day; the number of issues closing at the bid declines as the number of closes below and equal to the ask increases. Figures 5.5.A and 5.5.B also display the MI's for the first and tenth deciles. TS1's MI for decile 1 exhibits a clear swing toward ask-side closes the first week in January and declining thereafter. TS2 decile 1 MI exhibits a more pronounced swing to ask-side closes and captures the general bullish trend in the market.

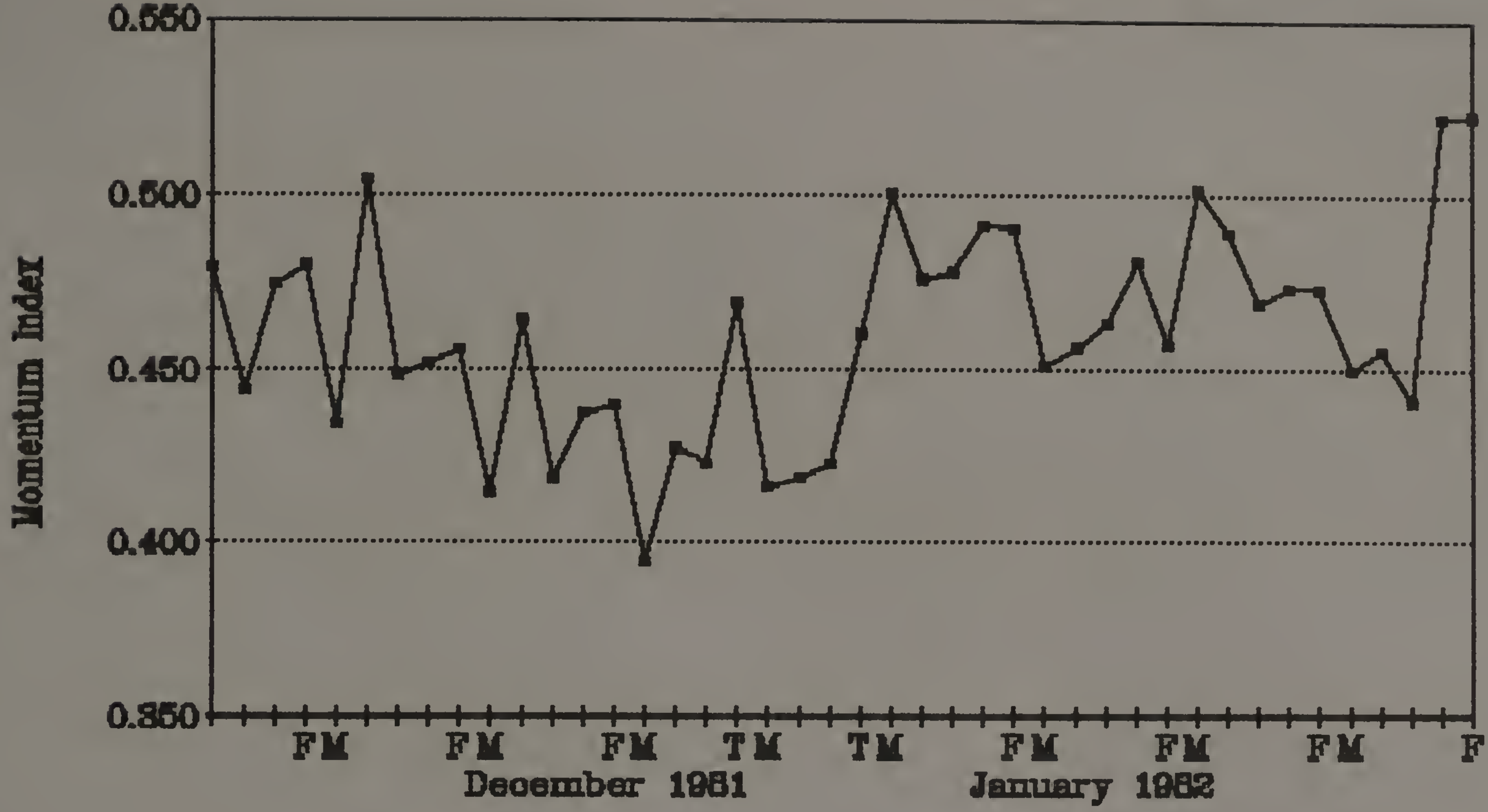

Figure 5.4.A. Average cross-sectional daily momentum index values for TS1. F = Friday, M = Monday, T = Thursday.

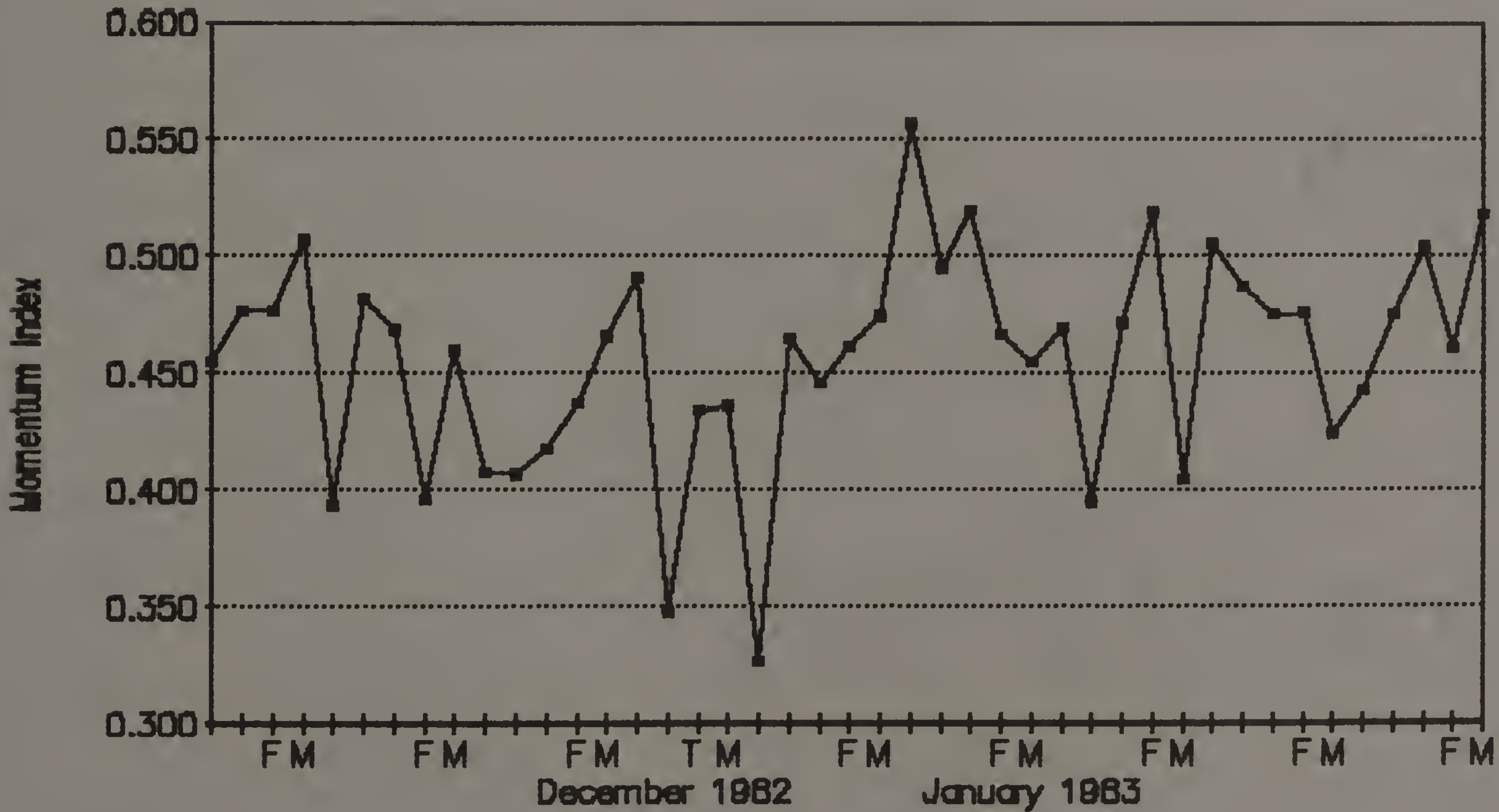

Figure 5.4.B. Average cross-sectional daily momentum index values for TS2. F = Friday, M = Monday, T = Thursday.

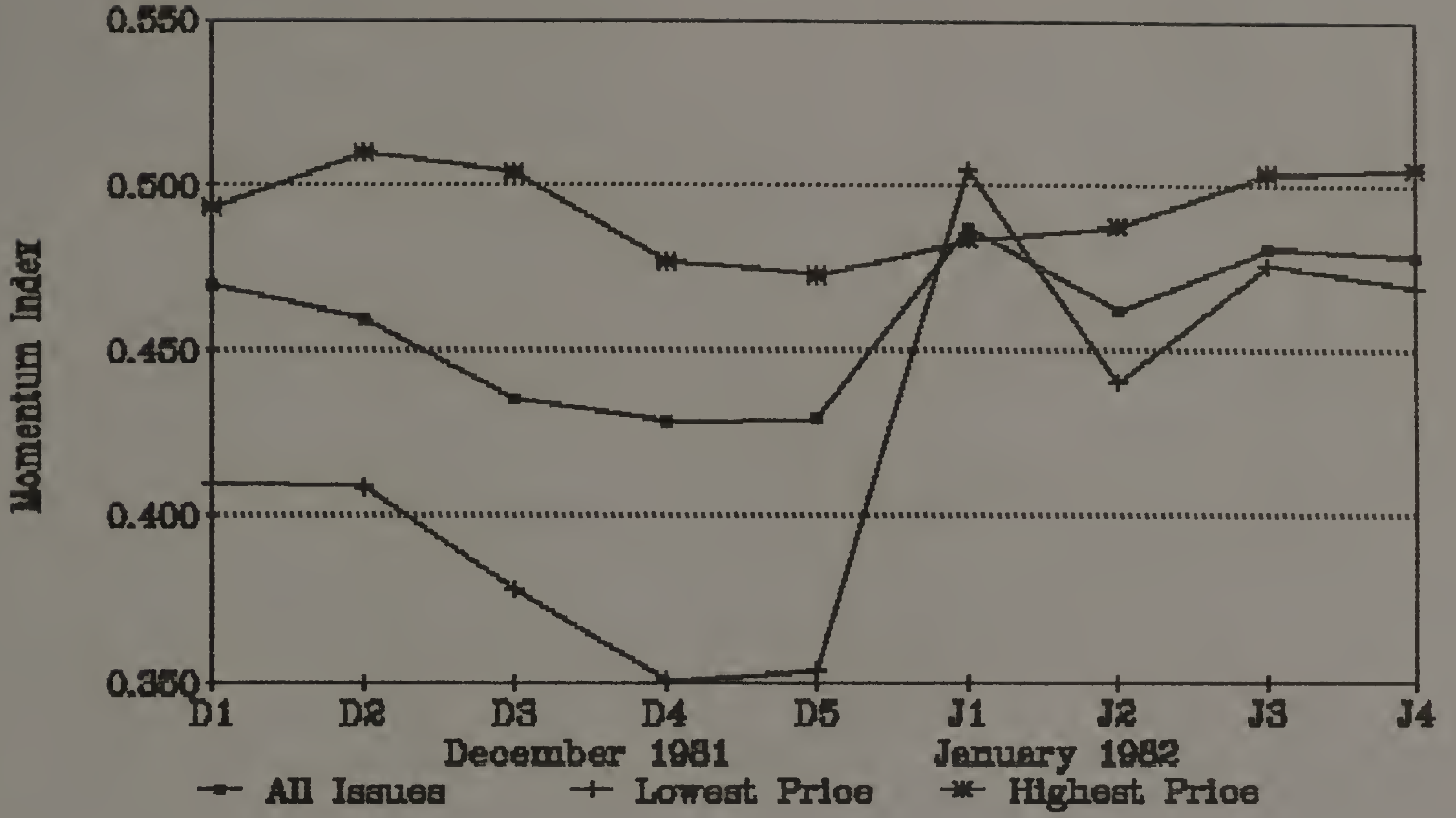

Figure 5.5.A. Weekly average cross-sectional momentum index values for TS1. F = Friday, M = Monday, T = Thursday.

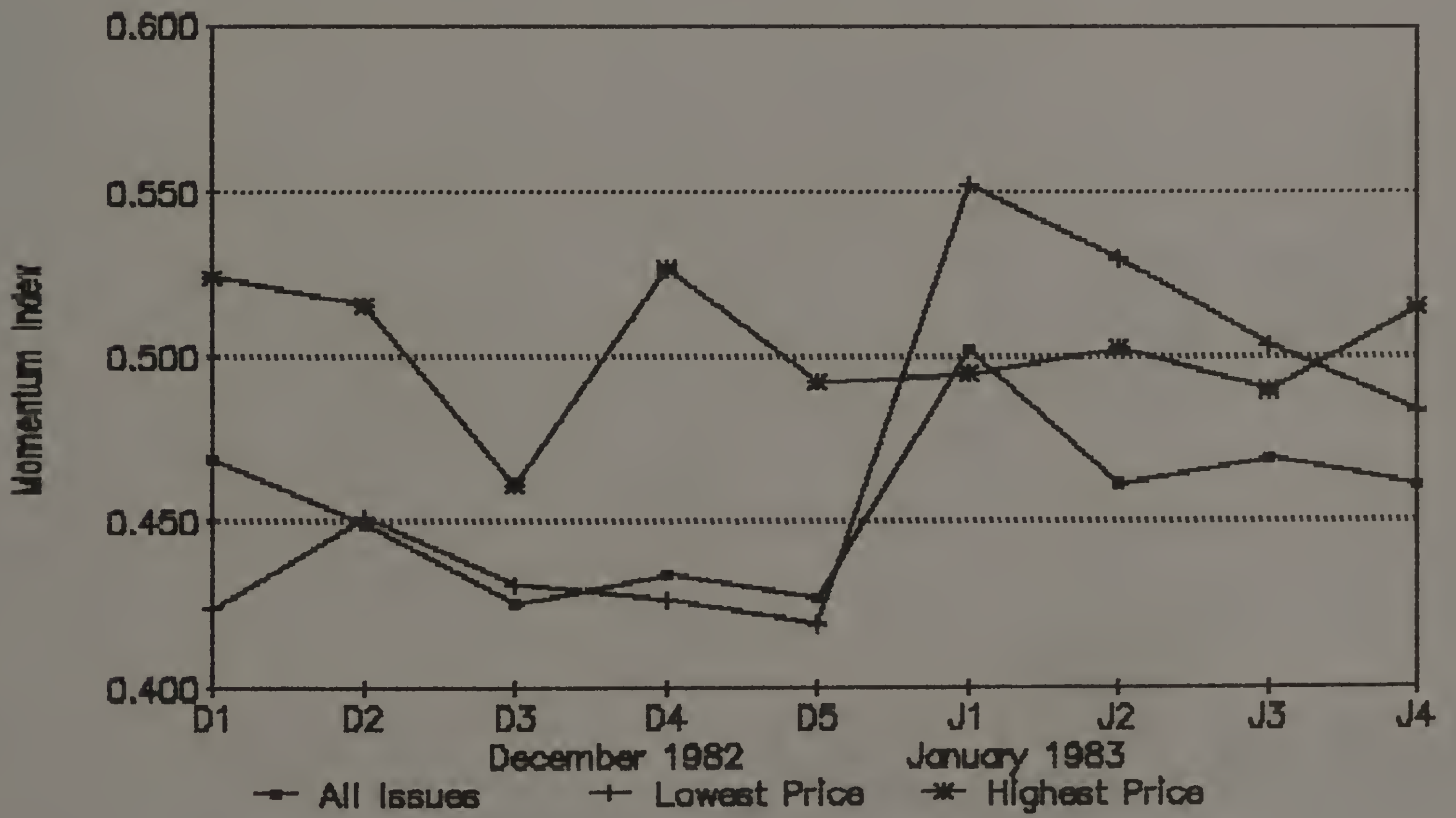

Figure 5.5.B. Weekly average cross-sectional momentum index values for TS2. F = Friday, M = Monday, T = Thursday.

5.7 Turn-of-the-Year Characteristics by Decile

Changes in relative bid-ask spreads may suggest a potential explanation for size effects or turn-of-the-year effects. Table 5.7, Panel A (p. 94), shows the average cross-sectional percentage spread per decile for each of the last three trading days in December and the first three days in January for TS1. Decile 1 (lowest price stocks) exhibits a steady rise in the percentage spread as the year draws to a close. Day 1 of the new year finds a substantial (and statistically significant at the .05 level) drop (12.8%) in the size of the spread, but rebounding quickly the second day and more or less stable as the week progresses. While several other deciles exhibit similar behavior between day -1 and day +1, none exhibit the magnitude of the first decile. None of the other nine deciles revealed any statistically significant changes in spread values during this time frame. Also, none of the other price deciles exhibit the monotone increase in percentage spread the last full week of trading for the "old" year.

Results for TS2 (Table 5.7, Panel B) reveal a slightly different trend in the lowest price decile. A 9.336% decline in the magnitude of the spread occurs on the second day in January. An examination of TS1 reveals an "up" day on the first trading day in January, 1982. This would indicate a decrease in the size of the average spread but by a substantially smaller percentage than actually occurred. TS2 experienced a "down" day on the first trading day in January 1983 and was "up" the next day. The 9.336% verification sample change in the (+2) spread for the lowest price decile is significant at the .10 level.

Table 5.7: Mean Daily Percentage Spread by Decile
Trading Date Relative to Year End

Panel A: Test Sample One (81-82)

Dec	-3	-2	-1	1	2	3
1	3.921	4.122	4.278	3.753	4.369	4.190
2	2.147	2.098	2.120	2.160	2.178	2.174
3	1.726	1.776	1.838	1.823	1.895	1.924
4	1.448	1.510	1.651	1.484	1.582	1.526
5	1.401	1.281	1.380	1.415	1.401	1.358
6	1.226	1.295	1.258	1.247	1.283	1.281
7	1.125	1.087	1.134	1.087	1.200	1.102
8	0.976	1.048	1.010	0.936	0.936	0.936
9	0.838	0.843	0.908	0.847	0.809	0.860
10	0.622	0.603	0.629	0.617	0.589	0.625

Panel B: Test Sample Two (82-83)

Dec	-3	-2	-1	1	2	3
1	3.760	3.620	3.701	3.738	3.389	3.506
2	2.004	1.929	2.089	2.112	2.019	1.885
3	1.649	1.605	1.781	1.639	1.569	1.609
4	1.381	1.397	1.385	1.586	1.379	1.398
5	1.211	1.300	1.253	1.337	1.262	1.281
6	1.173	1.159	1.178	1.203	1.122	1.152
7	1.058	1.047	1.084	0.942	1.024	1.054
8	0.847	0.894	0.946	0.932	0.915	0.960
9	0.742	0.740	0.733	0.757	0.790	0.767
10	0.601	0.574	0.582	0.605	0.599	0.588

Note: -1 = last trade date in December
 1 = first trade date in January

Roll (1983) suggested that a portion of the size effect results from the tendency of stocks to close at the ask side of the spread after the first of the year. One method for testing this suggestion is to utilize the Momentum Index. The Momentum Index is used to capture the combined effects of closing prices relative to the closing bid and ask price quotes. Table 5.8 (p. 94) displays momentum index (MI) values for the last three days in December and the first three days in January. The data indicates that, at least for this time period, low priced stocks were more likely to close at the ask after the first of the year. Test sample (Panel A) mean values for the momentum index are

.401 and .500 for December and January, respectively, for the first four price deciles. The difference between these two means is statistically significant at the .01 level. The values for TS2 (Panel B)

Table 5.8: Mean Daily Momentum Index by Decile
Trading Date Relative to Year End

Panel A: Test Sample One (81-82)

Dec	-3	-2	-1	1	2	3
1	0.283	0.360	0.444	0.491	0.508	0.508
2	0.409	0.397	0.440	0.494	0.499	0.471
3	0.421	0.467	0.437	0.506	0.526	0.524
4	0.370	0.420	0.365	0.520	0.472	0.486
5	0.406	0.427	0.463	0.485	0.418	0.471
6	0.469	0.425	0.439	0.468	0.457	0.488
7	0.460	0.384	0.488	0.451	0.480	0.451
8	0.430	0.426	0.507	0.503	0.434	0.405
9	0.470	0.431	0.464	0.533	0.527	0.477
10	0.460	0.473	0.537	0.546	0.453	0.503

Panel B: Test Sample Two (82-83)

Dec	-3	-2	-1	1	2	3
1	0.432	0.411	0.428	0.509	0.552	0.584
2	0.458	0.418	0.415	0.438	0.603	0.570
3	0.453	0.451	0.449	0.515	0.568	0.493
4	0.465	0.462	0.513	0.500	0.552	0.492
5	0.459	0.521	0.387	0.425	0.537	0.512
6	0.465	0.439	0.429	0.487	0.612	0.510
7	0.499	0.438	0.516	0.455	0.612	0.579
8	0.557	0.480	0.426	0.494	0.614	0.517
9	0.513	0.452	0.512	0.441	0.556	0.467
10	0.546	0.408	0.583	0.480	0.551	0.457

Note: -1 = last trade date in December
1 = first trade date in January

are .446 and .531 for December and January, respectively. The difference between these last two means is also significant at the .01 level.

Results reported in Table 5.7 and Table 5.8 reveal a consistent pattern of behavior for stock prices in the lower price deciles at the turn of the year, at least for the samples under observation. The higher price deciles exhibit little or no significant difference between the two time frames for either of the two sub-samples. The shift in closing prices from the bid to ask side for the lower price deciles would suggest that the higher returns reported in January, particularly for the lowest priced stocks, may not be the result of a fundamental change in intrinsic values. The higher returns result at least in part from a demand-induced shift from selling (at the bid) to buying (at the ask) before and after the turn of the year, respectively.

5.8. Preliminary Conclusions

This chapter examined the nature of the bias induced in returns measured using closing (last trade) prices compared to the use of closing bid and ask price quotes. We find a consistent over-estimation of returns (compared to those realized in actual trades) when closing prices are used. The bias is approximately the same for different length holding periods. The order of magnitude of the bias for each price decile examined tended to be approximately equal to the percentage spread for that decile. Low priced stocks tend to have the largest relative spreads and the greatest bias in close-to-close returns. Thus, the evidence suggesting the existence of a low price effect may be partially explained by nonlinear relative spread effects. The nonlinearity is the result of the 1/8 minimum spread imposed by the NYSE. The adoption of decimal spreads might result in a significant attenuation of the spreads on low price stocks. Quite possibly the size effect and the low price effect would also appear to be less strong. Finally, the magnitudes of the biases in computed returns examined in this chapter are also sensitive to the magnitude of the price level. The biases may also be sensitive to the use of daily returns in place of weekly, monthly, or even yearly holding periods when larger data samples are examined.

The magnitude of the bid-ask spread has been of interest in research by Roll (1984) and Glosten and Harris (1985). Both researchers have attempted to estimate the "effective" bid-ask spread by utilizing closing or intra-day transaction prices. Their estimates of the effective spread, defined as the spread paid by uninformed traders, have been substantially less that the actual bid-ask spreads measured in the current research. Moreover, the magnitude of the spread is fairly constant over a daily, weekly, or monthly assumed holding periods. Also, the bid-ask spread is positive for all deciles in the the sub-samples tested. We conclude tentatively that the attempt to measure "effective" bid-ask spreads using closing or transaction prices will result in substantially mis-estimated bid-ask spread effects and potential errors in the implications drawn from those estimates.

CHAPTER 6

RESULTS II

6.1 Observed Prices as True Prices

The first question to be addressed in this chapter concerns the identity of observed closing prices and "true" prices. On average, these prices should be identical or (at least) statistically equal. Blume and Stambaugh (1983), Glosten and Milgrom (1985), and others define "true" prices as the mean of the closing bid and ask price quotes. The true price is also termed the "expected closing price." We shall use the latter term for the balance of this analysis. In an efficient market, the average observed closing price should be equal to the expected closing price. Earlier we noted the Blume and Stambaugh (1983) suggestion that a "bid-ask effect" results in an upward bias in returns computed from closing prices. Although unspecified by Blume and Stambaugh, we suspect that the observed closing price should be slightly smaller than the expected closing price. Consider the following: Suppose the expected closing price on day (t-1) is $2.00 and the (average) observed closing price is $1.99 and the change in price on day (t) is (+) $0.125. The "expected return" is 6.25% and the "observed return" is 6.28%. The difference is a 0.03% upward bias in the computed return when observed closing prices are used to compute returns. Thus, a smaller denominator in the return computation algorithm results in larger return magnitudes for a given change in price. This section investigates the average ($) magnitude of the difference between observed closing prices and expected closing prices; $E\{e_i\} = E\{p_i - P_i\}$, where p_i is the observed price.

Test sample one (TS1) and test sample two (TS2) are stratified by price into deciles and means computed for the difference between observed and expected closing prices for each decile. The results are tabulated in Table 6.1. The average difference between observed closing prices (Ob) and expected closing prices (Ex) for each decile are displayed in the columns labeled "Ob-Ex." Column (1), Panel A, presents TS1 results; Column (4), Panel B, TS2 results. We test whether differences between observed closing prices and expected closing prices are significantly different from zero: The null hypothesis is (Ob-Ex) = 0.

Table 6.1: Observed versus Expected Closing Prices

	Panel A: TS1				Panel B: TS2			
	(1)	(2)	(3)		(4)	(5)	(6)	
Dec	Ob-Ex	t-test	MI	N	Ob-Ex	t-test	MI	N
1	-0.01184	-11.486	0.425	105	-0.00472	-4.577	0.475	109
2	-0.01268	-11.917	0.435	113	-0.00634	-5.568	0.474	110
3	-0.01014	-8.991	0.458	112	-0.00491	-4.421	0.479	145
4	-0.01316	-10.519	0.448	106	-0.00582	-4.436	0.483	100
5	-0.01020	-8.383	0.463	121	-0.00777	-6.542	0.473	130
6	-0.01066	-8.514	0.461	114	-0.00584	-4.684	0.480	132
7	-0.01005	-7.618	0.459	100	-0.00595	-4.300	0.481	118
8	-0.00896	-7.256	0.468	121	-0.00475	-2.910	0.485	118
9	-0.00559	-4.443	0.480	114	-0.00220	-1.645	0.495	124
10	-0.00369	-2.731	0.494	128	-0.00119	-0.632	0.503	119

The results in column (1), Panel A, indicate that observed closing prices are slightly smaller than expected closing prices and the differences are significant; Column (2) contains the t-values. Also, the average difference is approximately one cent and exhibits a monotone decline in magnitude as prices get larger. Columns (4) and (5) display the results for TS2. The mean differences reported in column (4) are smaller than those in column (1) and are significant for all but the ninth and tenth deciles.

The results reported in Table 6.1 are consistent and readily explainable by examining the momentum index (MI) for decile 1 in each sample (columns (3) and (6)). The TS1 MI value for decile 1 is .425 and the magnitude of the difference is -.0118. This value indicates that low price stocks in TS1 tended to close nearer the bid side. The corresponding values for TS2 are .475 and -.0047, respectively. TS2 low price stocks also tended to close nearer the bid side but to a lesser degree. The magnitude of the bias decreases as the MI value approaches .500. Although these results may very well be period specific, the consistency of the relationship in both panels between the MI and the magnitude of (Ob-Ex) suggests that the magnitude of any bias induced in average observed prices is a function of investor expectations (i.e., bullish or bearish) and institutional (NYSE) constraints on spreads. Accordingly, if stocks are in equilibrium and spreads are not restricted to a minimum increment of 1/8 point, no bias should be observed in closing prices. This does not seem to be the situation when we examine market microstructure behavior.

6.2 Observed Returns vs True Returns

The next question in this investigation addresses return measurement errors induced by the use of closing prices as equivalents for expected closing prices (true prices). Blume and Stambaugh (1983) suggest that the "bid-ask effect" results in significant estimation errors in returns computed from observed closing prices in contrast to returns computed from expected closing (true) prices. In their study they estimate the value of the average daily estimation bias as .051%. In section 6.1 we reported that a statistically significant difference exists between observed closing prices and expected closing prices. This section will test if the average magnitude of those differences is sufficient to produce a significant difference between observed returns and expected returns. Returns are computed for all stocks in each decile utilizing the three methods outlined by Roll (1983) and specified in equations (3.9), (3.10), and (3.11). Results are reported in Table 6.2 for TS1 (Panel A) and TS2 (Panel B).

Table 6.2: Observed minus Expected Returns (%)

Panel A: TS1

	Arithmetic		Buy/Hold		Rebalanced		
Dec	Ob-Ex	t	Ob-Ex	t	Ob-Ex	t	N
1	0.0209	0.5729	-0.0077	-1.1452	0.0206	0.5833	105
2	0.0051	0.3328	-0.0003	-0.1188	0.0050	0.2825	113
3	0.0050	0.4213	0.0018	0.9573	0.0049	0.5008	112
4	0.0047	0.4284	0.0021	0.9913	0.0047	0.3421	106
5	0.0037	0.3997	0.0016	1.2525	0.0036	0.4212	121
6	0.0009	0.1187	-0.0005	-0.4204	0.0009	0.1236	114
7	0.0022	0.2993	0.0011	1.0395	0.0022	0.2562	100
8	0.0005	0.0885	-0.0003	-0.3650	0.0005	0.0704	121
9	0.0021	0.4307	0.0016	2.2475	0.0021	0.4866	114
10	0.0011	0.3066	0.0008	1.4300	0.0011	0.2071	128
All	0.0044	1.0217	0.0000	0.0633	0.0044	0.7069	1134

Panel B: TS2

	Arithmetic		Buy/Hold		Rebalanced		
Dec	Ob-Ex	t	Ob-Ex	t	Ob-Ex	t	N
1	0.0284	0.8564	0.0033	0.6048	0.0338	0.8254	109
2	0.0090	0.6349	0.0044	1.8451	0.0097	0.5701	110
3	0.0031	0.3168	0.0002	0.0985	0.0038	0.3556	145
4	0.0023	0.2347	0.0003	0.1907	0.0027	0.2055	100
5	0.0021	0.2785	0.0005	0.5053	0.0030	0.3540	130
6	0.0006	0.0914	-0.0007	-0.6414	0.0004	0.0361	132
7	0.0001	0.0129	-0.0010	-0.8599	-0.0003	-0.0449	118
8	-0.0007	-0.1026	-0.0020	-1.9234	-0.0012	-0.1417	118
9	0.0009	0.1916	0.0003	0.4483	0.0003	0.0567	124
10	0.0017	0.4168	0.0013	2.3035	0.0016	0.2858	119
All	0.0045	1.1387	0.0006	0.9298	0.0051	0.8046	1205

Two important results are presented in Table 6.2. First, the magnitude of the differences in returns computed from observed closing prices are generally positive and less than the bias estimated by Blume and Stambaugh (1983). When arithmetic mean portfolio return differentials for decile 1 are computed, the magnitudes of the biases are .0209% and .0284% for TS1 and TS2, respectively. Second, the error magnitudes, while positive, are insignificantly different from zero. The results are quite similar when rebalanced portfolio return differentials are computed. The utilization of the buy/hold portfolio return algorithm results in an substantial attenuation of the bias, but the results are still insignificantly different from zero; -0.0077% and 0.0033% for TS1 and TS2, respectively.

The important implication of these results is that the "bid-ask effect" does not materially affect the reliability of daily returns generated utilizing observed closing prices instead of the mean of the closing bid and ask prices. The magnitudes of the biases will, however, impart larger errors when arithmetic and rebalancing return computation methods are used to examine size effects or low price effects. These errors could be substantial when longer holding period returns are computed utilizing daily closing price data.

The results reported in this section indicate that the error magnitude induced in computed returns by the bid-ask effect is substantially smaller than that reported by Blume and Stambaugh. Two reasons are offered for the difference in results achieved in this study. First, the Blume and Stambaugh study used a single day's closing bid and ask price data for 332 stocks. This single day's sample did not permit a sequence of expected closing prices to be estimated using the mean of the closing bid and ask price quotes. This series of expected prices would be important in computing true returns and for comparing those returns to returns computed using the observed closing price series. Second, the algorithm used by Blume and Stambaugh may be incorrectly specified in so far as estimating the average value of the bias is concerned. Their specification assumes that stocks will close at the bid or the ask with equal probabilities. Results reported earlier in Chapter 5 indicate that this is not necessarily the case. Moreover, the magnitude of the bias will depend upon the market's direction. A more precise method for measuring the magnitude of the bias would be to take the differences in holding period returns using expected closing prices and observed closing prices. That is the procedure followed in this section. The limited size of their sample may have produced the abbreviated procedure for estimating the average bias induced in the lowest price decile and the resulting misestimation of the bias. The results of the Blume and Stambaugh study are even less effective due to their very small sample. The larger samples used in the current investigation permitted better estimates of expected closing prices and expected (true) returns, and their comparison to observed closing prices and returns computed from those observed closing prices.

6.3 Size Effects

Size effect anomalies have received a substantial amount of attention in the recent literature. The methodologies most often employed require the estimation of historical betas (utilizing 60 months of returns), with and without the several beta correction procedures, (ie., Dimson betas) as measures of relative risk. These beta estimates are then utilized in one of the many forms of the pricing equation of the CAPM; typically the risk-adjusted return format incorporating a proxy for the risk free rate. Some researchers compute actual and forecast returns which are then differenced and the residuals examined within the framework of a statistical test. The test determines whether the residuals are significantly positive. Other researchers examine the intercept term using the risk-adjusted form of the CAPM pricing equation. If the average intercept is significantly positive for firms with small market values of equity or low prices, then size effects are said to exist.

All of the methodologies described above rely on beta as a relative measure of risk. As reviewed earlier, academic researchers disagree as to the validity of the small firm effect. The most frequently cited problems are the weak links between beta risk and return, and the problems related to nonsynchronous trading which result in under-estimation of risk when the CAPM is used to test market efficiency. Others note that the theory does not specify what determines the risk-free rate. Similar tests were performed in this study. [Market model] Betas, average returns and variances were estimated for all stocks in test sample one (41 days of returns). A correlation matrix was constructed and the following results noted: The correlations between betas and returns are weak; r^2's are typically less than .13. The correlations between average return and variances ($r^2 > .95$) are strong as are those between return variance and beta. Some researchers have suggested that the inclusion of the variance term in the market model improves the explanatory power of the model. This study does not suggest that the betas estimated using the relatively short time period are valid estimators of beta. The procedure is conducted to establish the generality of the relationships which exist between beta, return, and return variance when different price constructs are used. An alternative method is utilized in this study to test for the size effect which is not hampered by the beta estimation problems but relies instead on the strong relationship between return and variance (risk). In this section we examine the low price effect. Stoll and Whaley (1983), and others, have suggested that this method of analysis yields substantially the same results as the market value of equity (MVE) used in size effect studies. Moreover, the method employed in this section captures the same ordering of results typically reported in size effect studies which utilize MVE.

Size effect tests typically rely on returns computed from closing prices. Results reported earlier in this study have examined the extent to which these returns might be biased due to expected closing price measurement errors. The results reported in sections 6.1 and 6.2 indicate that while the differences between observed closing prices and expected closing prices are statistically significant, returns computed from the two price series are statistically identical.

The low price effect is tested by computing mean daily holding period returns and testing the difference between December and January portfolio returns. Mean daily holding period returns are estimated for each decile [portfolio] using equations (3.13), (3.14), and (3.15) corresponding to the three methods outlined in Roll (1983) for computing portfolio returns; arithmetic (AR), buy-hold (BH), and rebalanced (RB), respectively. Returns are measured close-to-close, ask-to-bid, and bid-to-ask. The last two simulate the use of market- and limit-orders to execute stock trades. Mean daily holding period returns for December (R_d) and January (R_j) are differenced and the residuals (Rj-Rd) tested for significance. The null hypothesis is E(Rj-Rd) = 0. If low price effects are part of the explanation for the January effect, then the difference between January and December returns should be significantly different from zero and positive for low price stocks. Accordingly, the critical value for the t-test is 1.658 for a single-tail test and the .05 level of significance. TS1 results are reported in Table 6.3.A; TS2 results in Table 6.3.B.

Discussion of the results is oriented by the method used to define trade execution prices and the methodology used to compute mean daily portfolio returns. Returns are measured using each of the Roll methodologies for each set of assumed transaction prices. The first section (6.3.1) focuses on TS1 results. Mean daily holding period returns based on the AR algorithm are analyzed first. AR returns are estimated using closing prices (CC), ask-to-bid prices (AB), and bid-to-ask prices (BA). This is followed by a discussion on mean portfolio returns utilizing the BH algorithm. A discussion of the RB algorithm results completes the analysis. A second section (6.3.2) analyzes TS2 results in the same manner.

6.3.1 Test Sample One (TS1) Results

A generalized review of the results presented in Table 6.3.A (p. 106) indicates that lower price stocks experienced generally positive or less negative returns in January. The most typical case was less negative returns in January compared to December. Higher price stocks experienced greater losses in January compared to December. With certain exceptions, most residuals (January returns minus December returns) were statistically equal to zero.

When portfolio returns are measured AR, the lowest price decile yields significantly positive residuals for close-to-close returns (t = 1.773). Returns measured ask-to-bid have a much smaller and insignificant (t= 0.179) January residual. Bid-to-ask returns have the largest and most significant January residual (t = 3.095). Stocks in the highest price decile experienced insignificantly negative January residuals for all three of the assumed price structures. Summary statistics for all stocks in TS1 show a slightly negative but insignificant January residual for close-to-close returns, significantly negative ask-to-bid returns, and significantly positive bid-to-ask returns. These results indicate a statistically significant low price effect. The price effect is smallest for returns measured ask-to-bid, reflecting the use of market orders.

The BH methodology results reveal substantially the same outcomes as the AR method: Significant but smaller positive January residuals for the lowest price decile. Residuals for the highest price decile are substantially lower than decile 1. The smaller magnitudes of the mean daily residuals in all deciles supports the Roll (1983) and Blume and Stambaugh (1983) suggestions that BH-based return measurements yield the smallest size-related effects. Similar to AR returns, returns measured ask-to-bid experience the smallest low price effects while those measured bid-to-ask experienced positive returns in both months. January bid-to-ask returns, however, were lower for higher priced deciles compared to December returns. The magnitudes of the lower January bid-to-ask returns were not significantly different. Bid-ask spreads were larger in January reflecting lower prices, and

Table 6.3.A: Low Price Effects Jan-Dec Return Differentials

Test Sample One

Retns	Dec	ROLL AR Rj-Rd	ROLL AR t	ROLL BH Rj-Rd	ROLL BH t	ROLL RB Rj-Rd	ROLL RB t	N
CC		0.204	1.773	0.185	2.353	0.202	1.562	105
AB	1	0.020	0.179	0.012	0.046	0.018	0.152	105
BA		0.385	3.095	0.371	1.354	0.383	3.118	105
CC		0.038	0.523	0.035	0.662	0.037	0.395	113
AB	2	-0.085	-1.192	-0.089	-0.917	-0.086	-0.982	113
BA		0.162	2.166	0.156	1.972	0.160	1.732	113
CC		0.028	0.397	0.024	0.437	0.026	0.263	112
AB	3	-0.098	-1.452	-0.100	-1.177	-0.099	-1.064	112
BA		0.125	1.793	0.121	1.677	0.123	1.253	112
CC		0.073	1.149	0.064	1.250	0.070	0.741	106
AB	4	-0.002	-0.030	-0.010	-0.131	-0.004	-0.044	106
BA		0.110	1.746	0.101	1.535	0.107	1.176	106
CC		0.015	0.254	0.007	0.129	0.012	0.134	121
AB	5	-0.054	-0.957	-0.063	-0.952	-0.057	-0.640	121
BA		0.076	1.301	0.067	1.089	0.074	0.813	121
CC		-0.118	-1.940	-0.126	-2.654	-0.122	-1.104	114
AB	6	-0.205	-3.415	-0.212	-3.102	-0.209	-1.954	114
BA		-0.044	-0.718	-0.053	-0.906	-0.049	-0.438	114
CC		-0.147	-2.327	-0.157	-3.245	-0.151	-1.422	100
AB	7	-0.210	-3.397	-0.219	-3.390	-0.214	-2.060	100
BA		-0.083	-1.311	-0.092	-1.568	-0.086	-0.816	100
CC		-0.055	-1.030	-0.063	-1.326	-0.058	-0.599	121
AB	8	-0.075	-1.411	-0.082	-1.359	-0.078	-0.818	121
BA		-0.034	-0.630	-0.041	-0.812	-0.037	-0.374	121
CC		-0.061	-1.060	-0.070	-1.510	-0.066	-0.542	114
AB	9	-0.121	-2.140	-0.130	-2.222	-0.126	-1.065	114
BA		-0.016	-0.279	-0.025	-0.490	-0.021	-0.174	114
CC		-0.038	-0.827	-0.046	-1.121	-0.042	-0.410	128
AB	10	-0.062	-1.350	-0.070	-1.285	-0.066	-0.656	128
BA		-0.015	-0.324	-0.023	-0.476	-0.019	-0.185	128
			Summary Statistics					
All CC		-0.007	-0.345	-0.016	-0.948	-0.010	-0.323	1134
All AB	S	-0.089	-3.983	-0.096	-1.952	-0.091	-3.040	1134
All BA		0.064	2.709	0.056	1.093	0.061	1.958	1134

lower volumes. These observations indicate that the specialist is still able to earn positive returns even in a down market.

The RB method reveals residuals quite similar in magnitude and significance to AR method results. These results are consistent with Roll's (1983) suggestions; AR > BH and RB > BH. Also, RB ask-to-bid residuals are uniformly smaller and less significant than close or bid-to-ask returns. The TS1 results demonstrate that the magnitude of low price effects (and most likely size effects) are sensitive to the return measurement algorithms. Moreover, the magnitudes of the residuals as well as returns are particularly sensitive to the assumed transaction price structures.

6.3.2 Test Sample Two (TS2) Results

The results reported for TS1 are influenced by a bearish move by the market in general. The results reported in Table 6.3.B for TS2 are influenced by a bull market move. Accordingly, the test results reported herein reflect the significant effects of that market trend. In general, January returns were more positive than December returns for all deciles and is reflected by the positive values for all residuals. January residuals were largest for the lowest price decile. Moreover, the largest magnitude of the residual occurs for returns measured ask-to-bid. Two reasons account for this result. First, higher prices typically result in smaller bid-ask spreads. Second, the substantial positive move by lower price stocks attenuated the effect of the spread on measured returns. This was uniformly the case for all price deciles except the tenth (largest price) decile.

Table 6.3.B: Low Price Effects Jan-Dec Return Differentials

Test Sample Two

		ROLL AR		ROLL BH		ROLL RB		
Retns	Dec	Rj-Rd	t	Rj-Rd	t	Rj-Rd	t	N
CC		0.590	4.777	0.574	6.726	0.581	3.475	109
AB	1	0.746	6.038	0.739	2.968	0.738	4.757	109
BA		0.289	2.159	0.281	1.046	0.282	1.721	109
CC		0.324	3.562	0.324	4.538	0.318	2.245	110
AB	2	0.424	4.386	0.438	4.254	0.419	3.124	110
BA		0.158	1.592	0.171	2.006	0.152	1.085	110
CC		0.145	2.276	0.143	2.824	0.142	1.392	145
AB	3	0.233	3.505	0.232	3.215	0.230	2.331	145
BA		0.049	0.722	0.048	0.717	0.046	0.455	145
CC		0.219	2.913	0.214	3.479	0.215	1.719	100
AB	4	0.277	3.578	0.278	3.236	0.274	2.276	100
BA		0.135	1.710	0.137	1.955	0.131	1.065	100
CC		0.140	2.119	0.138	2.601	0.137	1.239	130
AB	5	0.187	2.843	0.186	2.676	0.184	1.714	130
BA		0.093	1.389	0.092	1.458	0.089	0.802	130
CC		0.136	2.036	0.130	2.302	0.133	1.187	132
AB	6	0.168	2.162	0.160	2.319	0.165	1.467	132
BA		0.103	1.305	0.095	1.591	0.101	0.884	132
CC		0.141	2.105	0.131	2.357	0.137	1.146	118
AB	7	0.182	1.781	0.185	2.725	0.178	1.432	118
BA		0.089	0.859	0.092	1.549	0.084	0.660	118
CC		0.180	2.626	0.177	3.300	0.178	1.385	118
AB	8	0.194	2.271	0.172	2.210	0.191	1.442	118
BA		0.198	2.204	0.171	2.925	0.195	1.473	118
CC		0.035	0.539	0.023	0.438	0.034	0.267	124
AB	9	0.054	0.833	0.043	0.683	0.053	0.426	124
BA		0.015	0.227	0.003	0.062	0.013	0.107	124
CC		0.097	1.262	0.068	0.847	0.096	0.675	119
AB	10	0.087	1.138	0.060	0.641	0.087	0.615	119
BA		0.108	1.392	0.080	0.953	0.107	0.750	119
			Summary Statistics					
All CC		0.193	7.970	0.185	9.153	0.190	4.979	1205
All AB		0.247	9.073	0.241	5.584	0.243	6.550	1205
All BA		0.119	4.174	0.112	2.316	0.116	3.041	1205

Returns measured BH were typically negative and less so in January compared to December. This reflects the narrowing of bid-ask spreads as stock prices get larger. The difference in magnitudes of the BH residuals compared to AR and RB residuals are quite small; typically less than three basis points. This should not be interpreted to mean that the same level of return was experienced by all three return measurement methods. It reflects the uniformity of effects as bid-ask spreads begin to narrow. The important implication of this finding is the effect that the bid-ask spread has on realized returns.

The results discussed in the last two sections suggest that the low price effect may be sensitive to the methodology and time sample used to measure returns. In bear markets, the low price effect may be the result of the specification of the return generating process. Specifically, when returns are generated using close-to-close prices, significant low price effects are present in the lowest price decile. When returns are generated in a manner consistent with market order executions, size effects are reduced to insignificance. In bull markets, the opposite appears to be true. When returns are generated using ask-to-bid prices (market-order executions), low price effects are significant. Returns measured bid-to-ask, however, are less significant. This would suggest that the specialist/market maker earns less at the margin during up markets due to a narrowing of the bid-ask spread. The issue is more complicated. The spread may reflect more limit order activity on the bid side. Also, we cannot overlook the possibility of specialist inventory profits in up markets offsetting any losses in income due to a narrowing of the bid-ask spread.

The general implications of the preceding analysis suggests that the low price effect is sensitive to time, market characteristics, and the method used to examine return differentials. The strength of the effect is largely a function of the methodology used to measure returns and the nature of the samples used to test the effect. This observation has been made by other research results indicating an instability of the effect. We cannot dismiss the notion that some degree of market inefficiency is at work in the low price effect anomaly and most probably in the size effect. The origin of the inefficiency, however, is not the market per se. The low price effect is most likely related to the behavior of the spread and in particular the minimum spread imposed by the NYSE for stocks trading in excess of one dollar. When stocks rise sufficiently in price, particularly low price stocks, the mean bid-ask spread predicted by the model implied in section 6.1 may result in an attenuation of the low price effect. A simple elimination of the 1/8 point spread increments might achieve the same result; ie., use of decimal spreads.

6.4 Weekend Effects

Weekend effects are tested in a manner similar to the testing of low price effects. Monday-to-Tuesday (MT) returns are subtracted from Friday-to-Monday (FM) returns and the residuals tested for significance. The null hypothesis is E{MT-FM} = 0. Due to the relatively small sample, the two holiday weekend returns (Christmas and New Years) are included. This procedure may bias the results. The bias, if present, should act equally on all return computation methods. Accordingly, the results should be useful in understanding the nature of the weekend effect. Also, one might expect weekend returns to be substantially larger than weekday returns. This expectation would be conditioned on the belief that returns occur in calender time. Accordingly, weekend returns (3 days) should be three times as large as weekday returns. The objective of the French (1980) study was to determine the answer to that question. French's results suggested that returns occur in trading time rather than calender time.

A potentially important influence on weekend effects is the incidence of ex-dividend dates. Table 6.4 presents the distribution of ex-dividend dates for TS1. 495 stocks went ex-dividend during the sample period; 188 stocks (38%) went ex-dividend on Monday as opposed to 37 stocks (7%) going ex-dividend on Friday. We would expect, in the absence of any other effects, that average closing prices on Fridays would be higher than average closing prices on Mondays. This expectation is based on the generally observed tendency of ex-dividend day share prices to recover less that the total amount of the dividend by the close of trading on the ex-date.

Table 6.4: Frequency Summary for Ex-Dividend Days By Days of the Week for Test Sample One

Week	Mon	Tues	Wed	Thurs	Fri	Total
Dec1	*	16	6	5	15	42
Dec2	30	24	40	7	9	110
Dec3	28	15	8	7	6	64
Dec4	9	6	3	37	H	55
Dec5	27	8	2	2	H	39
Jan1	28	8	3	1	1	41
Jan2	33	7	1	3	1	45
Jan3	16	8	3	1	3	31
Jan4	17	33	11	5	2	68
Total	188	125	77	68	37	495
%	38	25	16	14	7	100

Note: Dec1 = first week in December, etc.
H = Holiday, NYSE closed

The data for TS2 indicate 579 stocks going ex-dividend during the sample time period. The distribution of ex-dates for TS2 are: 245 (42%), 133 (23%), 67 (12%), 86 (15%), and 48 (8%) for Monday through Friday, respectively. Thus the two samples have approximately the same distribution of ex-dates. The distributions shown in Table 6.4 would support a marked potential for negative Friday-to-Monday returns for stocks that go ex-dividend on Monday.

The possibility of substantial ex-dividend date effects suggests that the data sample be dichotomized on that basis. Accordingly, results are reported for non-dividend paying stocks, stocks going ex-dividend and combined results for each decile in the sample. Also, returns are measured close-to-close, ask-to-bid, and bid-to-ask. Table 6.5.A (p. 113) presents the results for TS1, Table 6.5.B (p. 114) for TS2. D = (%) difference in returns, t = test statistic, and N = the number of issues.

The last three rows in Table 6.5.A contain the summary statistics for all stocks in TS1. The weekend effect is present in eight of the nine categories. When returns are measured close-to-close, TS1 results indicate significantly negative residuals in six of the ten deciles. When returns are measured ask-to-bid, five deciles have significantly negative residuals and only three deciles have significantly negative residuals when returns are measured bid-to-ask. Effects are most significant in the third, sixth, and eighth deciles. In all deciles, the evidence of a weekend effect is weakest in non-dividend paying stocks; 7 out of 30 possibilities. The evidence is strongest in stocks going ex-dividend; 15 out of 30. Also, the weekend effects are weakest in the lowest and highest price deciles.

Table 6.5.A: Weekend Effect under Alternative Assumptions
Return Differentials and Dividend Effects

Test Sample One

	Dec	Close-to-Close No	Close-to-Close Div	Close-to-Close Comb	Ask-to-Bid No	Ask-to-Bid Div	Ask-to-Bid Comb	Bid-to-Ask No	Bid-to-Ask Div	Bid-to-Ask Comb
D		-0.39	0.06	-0.33	-0.28	-0.08	-0.25	-0.25	0.02	-0.21
t	1	-1.8	0.18	1.71	-0.87	-0.15	0.87	-0.68	0.05	0.65
N		91	14	105	91	14	105	91	14	105
D		-0.17	-0.3	-0.22	-0.16	-0.19	-0.17	-0.16	-0.14	-0.15
t	2	-1.18	-1.89	2.02	-0.89	-1.03	1.3	-0.98	-0.75	1.24
N		70	43	113	70	43	113	70	43	13
D		-0.46	-0.34	-0.4	-0.44	-0.36	-0.4	-0.45	-0.37	-0.41
t	3	-2.7	-2.27	3.54	-2.37	-2.02	3.11	-2.44	-2.63	3.55
N		56	56	112	56	56	112	56	56	112
D		-0.09	-0.4	-0.23	-0.22	-0.36	-0.29	-0.03	-0.31	-0.16
t	4	-0.69	-3.28	2.52	-1.49	-2.89	2.91	-0.18	-2.23	1.48
N		57	49	106	57	49	106	57	49	106
D		-0.05	-0.02	-0.04	-0.06	-0.09	-0.07	-0.06	0.06	0
t	5	-0.4	-0.15	0.39	-0.44	-0.61	0.75	-0.5	0.42	0
N		60	61	121	60	61	121	60	61	121
D		-0.23	-0.34	-0.28	-0.23	-0.4	-0.31	-0.25	-0.3	-0.27
t	6	-1.83	-2.49	3.04	-1.62	-2.74	3.02	-1.91	-2.16	2.88
N		62	52	114	62	52	114	62	52	114
D		0	-0.06	-0.03	-0.05	-0.13	-0.09	0.09	-0.12	-0.01
t	7	0.03	-0.38	0.25	-0.35	-0.94	0.91	0.58	-0.69	0.12
N		51	49	100	51	49	100	51	49	100
D		-0.16	-0.28	-0.21	-0.22	-0.31	-0.26	-0.15	-0.27	-0.2
t	8	-1.44	-2.16	2.54	-1.94	-2.44	3.09	-1.31	-1.91	2.29
N		67	54	121	67	54	121	67	54	121
D		0.02	-0.25	-0.1	-0.11	-0.28	-0.19	0.02	-0.22	-0.09
t	9	0.19	-1.93	1.22	-0.95	-2.16	2.19	0.17	-1.58	0.98
N		61	53	114	61	53	114	61	53	114
D		0.09	0.04	0.07	-0.02	-0.01	-0.01	0.11	0.07	0.09
t	10	0.9	0.41	0.94	-0.18	-0.08	0.19	1.04	0.8	1.25
N		76	52	128	76	52	128	76	52	128
	Summary Statistics									
D		-0.15	-0.2	-0.17	-0.18	-0.23	-0.2	-0.11	-0.17	-0.14
t		-3.16	-4.55	5.18	-2.14	-3.92	3.67	-1.27	-2.74	2.36
N		651	483	1134	651	483	1134	651	483	1134

Table 6.5.B: Weekend Effect under Alternative Assumptions
Return Differentials and Dividend Effects

Test Sample Two

		Close-to-Close			Ask-to-Bid			Bid-to-Ask		
	Dec	No	Div	Comb	No	Div	Comb	No	Div	Comb
D	1	-0.14	-1	-0.21	-0.14	-0.28	-0.2	-0.55	-0.16	-0.31
t		-0.68	-1.81	1.09	-0.73	-1.97	1.69	-1.54	-0.88	1.75
N		100	9	109	100	9	109	100	9	109
D	2	-0.12	-1.04	-0.2	-0.17	-0.29	-0.22	-0.3	-0.36	-0.33
t		-0.4	-1.9	0.69	-0.97	-2.04	1.97	-2.33	-3.32	3.93
N		70	40	110	70	40	110	70	40	110
D	3	-0.19	-0.89	-0.25	-0.37	-0.29	-0.33	-0.57	-0.26	-0.41
t		-0.58	-1.55	0.8	-2.81	-2.12	3.51	-3.39	-1.53	3.42
N		78	67	145	78	67	145	78	67	145
D	4	-0.12	-0.08	-0.11	-0.37	-0.3	-0.34	-0.54	-0.52	-0.53
t		-0.67	-0.4	0.78	-2.63	-2.2	3.44	-3.01	-3.02	4.28
N		54	46	100	54	46	100	54	46	100
D	5	-0.15	0.12	-0.05	-0.38	-0.25	-0.32	-0.2	-0.28	-0.24
t		-0.78	0.51	0.36	-2.64	-1.82	3.19	-1.8	-2.43	3.02
N		69	61	130	69	61	130	69	61	130
D	6	-0.05	0.05	-0.01	-0.1	-0.33	-0.23	-0.2	-0.32	-0.26
t		-0.26	0.21	0.1	-0.71	-2.91	2.53	-1.81	-2.69	3.22
N		60	72	132	60	72	132	60	72	132
D	7	-0.21	-0.34	-0.27	-0.3	-0.3	-0.3	-0.16	-0.28	-0.23
t		-1.65	-2.46	2.88	-1.67	-1.99	2.58	-1.52	-2.46	2.85
N		46	72	118	46	72	118	46	72	118
D	8	-0.27	-0.37	-0.31	-0.26	-0.19	-0.22	-0.19	-0.09	-0.14
t		-1.84	-2.73	3.14	-1.48	-1.07	1.76	-1.54	-0.83	1.73
N		59	59	118	59	59	118	59	59	118
D	9	-0.25	-0.36	-0.3	-0.21	-0.18	-0.19	-0.25	-0.44	-0.35
t		-1.71	-2.54	2.94	-1.55	-1.69	2.29	-1.72	-1.7	2.36
N		60	64	124	60	64	124	60	64	124
D	10	-0.04	-0.27	-0.15	-0.58	-0.2	-0.35	-0.22	-0.12	-0.17
t		-0.21	-2.13	1.33	-1.65	-1.08	1.96	-1.66	-1.16	2.03
N		62	57	119	62	57	119	62	57	119
					Summary Statistics					
D		-0.18	-0.27	-0.22	-0.18	-0.24	-0.21	-0.2	-0.27	-0.23
t		-3.63	-6.28	-6.55	-2.23	-4.61	-4.1	-2.22	-5.2	-4.21
N		658	547	1205	658	547	1205	658	547	1205

These results support two possible conclusions. First, the weekend effect is very sensitive to the incidence of ex-dividend date price adjustments. Second, the weekend effect is not equally distributed among different price levels. This might suggest an interaction between the price level and the magnitude of the dividend. However, due to the size of the samples, any findings of weekend effects should be interpreted with caution.

The last three rows in Table 6.5.B contain the results for all stocks TS2. The weekend effect is present in all nine categories. When returns are measured close-to-close, only three of the ten deciles have statistically significant negative residuals. When returns measured ask-to-bid or bid-to-ask, all ten deciles have statistically significant negative residuals In all deciles, the evidence of a weekend effect is weakest in non-dividend paying stocks; 11 out of 30 possibilities. The evidence is strongest in stocks going ex-dividend; 20 out of 30. Similar to the TS1 results, effects are weakest in the lowest and highest price deciles. The TS2 results are substantially similar to the TS1 results and support the same level of conclusions suggested in the previous paragraph.

6.5 The January Effect

The January effect is the tendency of stocks reaching year end lows in December to experience significant gains after the first of the year. A problem in examining the January effect is that it may be associated with or indeed part of the size effect, low price effect, or may be confounded by one or both of these effects. Some research has suggested that stocks with absolute gains in December or earlier may continue to experience gains after the new year. Alternatively, not every stock reaching year-end lows in December will experience any significant gains in January. We are interested in examining the January effect under alternative assumptions about the form of the return generating process. Accordingly, we examine turn-of-the-year behavior with returns measured close-to-close, ask-to-bid, and bid-to-ask. The primary focus of our investigation is the behavior of the first (lowest) and tenth (highest) price deciles.

The data samples are examined for a January effect by testing the difference between mean daily January and December close-to-close returns. The TS1 lowest price decile t-test is 2.54; the highest price decile is -.799. The test results indicate a January effect in the lowest price decile. January returns for the highest price decile were more negative than December returns but the difference is insignificantly different from zero. When returns are measured ask-to-bid or bid-to-ask, test results are quite similar: January returns are more positive for the lowest price decile, and more negative for the highest price decile. Unlike close-to-close returns, none of the latter results are statistically significant. Tests of TS2 indicate substantially greater January returns compared to December returns for the three alternative return generating processes. The results were expected: the market evidenced a substantial bull move during January 1983. The t-test values for the TS2 lowest and highest price deciles were 6.42 and 3.11, respectively. An additional test of the difference between January returns for the lowest and highest price deciles indicates a significantly more positive return for the lowest price decile. The t-test values are 1.97 and 6.63 for TS1 and TS2, respectively.

We next divide each the lowest and highest price deciles into quintiles and examine the January effect in greater detail. In effect, five portfolios each (total of ten) are formed with the stocks in the lowest and highest price deciles. Stocks are assigned to these portfolios on the basis of December returns; stocks with the lowest positive or most negative returns are assigned to portfolio 1, those with the highest positive or least negative returns are assigned to portfolio 5. The five portfolios within each decile contain the same number of stocks within plus or minus one. Table 6.6 contains the t-test results of these comparisons for TS1 and TS2.

Table 6.6: January-December Return Differentials

Panel A: TS1 t-Test Results

	Lowest Price Decile			Highest Price Decile		
Pf	CC	AB	BA	CC	AB	BA
1	6.199	1.558	0.254	2.892	2.208	3.084
2	3.268	1.036	0.508	0.074	-0.227	0.280
3	3.018	0.853	1.234	0.575	0.629	0.442
4	1.036	-0.053	0.273	-3.642	-2.017	-3.784
5	-4.898	-0.959	-0.854	-2.365	-1.310	-1.758
All	2.541	0.922	0.448	-0.799	-0.469	-0.908

Panel B: TS2 t-Test Results

	Lowest Price Decile			Highest Price Decile		
Pf	CC	AB	BA	CC	AB	BA
1	11.01	2.758	1.193	7.731	6.168	7.273
2	7.610	2.817	1.716	4.100	2.000	2.697
3	3.475	2.002	0.649	1.581	1.403	1.259
4	2.356	1.995	-0.444	-0.197	-0.119	-0.150
5	-2.293	0.302	-0.633	-3.504	-2.844	-3.025
All	6.424	3.733	0.778	3.109	2.521	4.453

In general, stocks in the first quintile, those experiencing the worst returns in December, show the largest positive differentials between January and December returns; those experiencing the best December returns (fifth quintile) experience the largest negative differentials in January. The magnitudes of the return differentials decline in near monotone order from the first to the fifth quintiles. (Critical value for the t-test = 2.080.)

Results describing return differences for the lowest price decile were presented in section 6.3. The results described therein clearly show more positive returns accruing to low-priced stocks in comparison to the high-priced stocks. Table 6.6 provides an additional dimension to the investigation. A further categorization based on December returns for stocks in the lowest and highest price deciles reveals an additional regularity. Stocks in the lowest return quintiles experience strong January effects regardless of price decile. Stocks in the highest return quintiles experience statistically significant lower January returns. Differentials for the lowest price decile are significant for returns measured close-to-close and ask-to-bid and insignificant for returns measured bid-to-ask . The results are generally significant for the lowest and highest return quintiles of the highest price decile regardless of the assumptions made about the return generating process.

Tax considerations have been suggested as an explanation for part of the turn-of-the-year or January effect. Accordingly, December would seem the best time (from a tax standpoint) to recognize losses and January to realize gains. The regularity of the return behavior of the first and fifth quintiles suggests the possibility of a rotation in the flow of investment during January from those stocks with the best December performances to those with the worst; with part or all of the rotation occurring in January. Two additional observations are made. First, test sample one average daily trading volumes for the lowest price decile were uniformly lower in January compared to December. The average daily trading volume decline in the fifth quintile (37%) was slightly greater than the first quintile (34%). Second, average daily trading volumes for the highest price decile were uniformly larger in January compared to December; 34% greater in the fifth quintile and 28% for the first quintile. The results are contained in Table 6.7.

Table 6.7: January versus December Trading Volumes
Test Sample One

	Low Price Decile			High Price Decile		
Pf	Jan Vol	Dec Vol	t-test	Jan Vol	Dec Vol	t-test
1	16757	25543	-0.907	61679	48035	1.093
2	17413	19454	-0.315	90093	71005	0.697
3	10559	12343	-0.449	51086	41496	0.858
4	9866	15856	-1.384	80744	49297	1.174
5	13666	21733	-1.669	84278	62525	0.596
All	13652	18985	-1.881	73391	54383	1.699

Statistical t-tests of the differences in trading volumes reveals insignificant differences when January volumes and December volumes are compared. These observations would suggest that, at least for TS1 (bear market), January gains in low price stocks occur on lower volumes; losses in the highest priced stocks occur on larger volume. The differences between January and December trading volumes are significant at the .10 level; t-test results are -1.881 and 1.699 for the lowest and highest price deciles, respectively. The lower January trading volumes for the lowest price stocks might suggest a partial explanation for the January effect, at least for the lowest priced stocks. Lower volumes suggest a decrease in liquidity. A decrease in liquidity is also accompanied by an increase in the bid-ask spread.

Both are indicative of increased levels of risk. If the relationship between risk and return holds. then postive January returns for low price stocks would be a partial result of the increase in the apparent riskiness of these low priced securities. These results are, of course, very speculative due to the very small sample of stocks. It does, however, reveal a potentiallly important relationship between the interaction of volumes, bid-ask spreads and observed returns. A more detailed analysis with larger data samples might be useful in increasing our understanding of this particular anomaly.

These results suggest that the magnitude of the January effect (or turn-of-the-year effect) is sensitive to the underlying trend of the market; the effect is stronger in a bull market. The results also indicate that the effect is non-uniform across a price-stratified sample. When a price decile is further stratified on the basis of December performance, stocks in the worst December returns quintile substantially outperform those in the best December performance regardless of the underlying trend in the market. Finally, the results suggest that the January effect is most significant when returns are measured close-to-close and least significant when returns are measured bid-to-ask (limit orders) for the lowest price decile: The results for the highest price decile are significant regardless of the assumptions made about the form of the return generating process.

6.6 Microstructure Price Behavior and Autocorrelation

We now investigate the relation between today's closing price relative to the closing bid and ask price quotes and the next day's price change. We are interested in determining the extent of regularities in price changes when stocks close at the bid, ask, inside, or outside the closing bid-ask spread. To facilitate our investigation, we have stratified the sample into deciles using the daily closing price as the stratification variable. This procedure minimizes the effects of different price/spread levels present in the overall sample. The very low number of securities closing outside the closing bid-ask price spread precludes separate estimates for means and variances of next day price changes. Accordingly, three categories are reported: closes<=bid; bid< close <ask; and close >= ask. In each category, the scale of the (t+1) change is always relative to the magnitude of the day(t) bid-ask spread. Thus, changes in the (t+1) closing spread, bid, ask are given as percentages using equations (6.1),(6.2), and (6.3), respectively.

$$\%D_{spr} = \frac{(Ask_{t+1} - Bid_{t+1}) - (Ask_t - Bid_t)}{(Ask_t - Bid_t)} \qquad (6.1)$$

$$\%D_{ask} = (Ask_{t+1} - Ask_t) \;/\; (Ask_t - Bid_t) \qquad (6.2)$$

$$\%D_{bid} = (Bid_{t+1} - Bid_t) \;/\; (Ask_t - Bid_t) \qquad (6.3)$$

An important result of using time t's spread as a scale is demonstrated in the subsequent tables. The percentage change in the (t+1) spread (%CHG S) is equal to the algebraic difference between changes in the ask (%CHG A) and bid (%CHG B) quotes; equation (6.2) minus equation (6.3) equals equation (6.1). The price-stratified samples suggest that the magnitudes of the next day changes are sensitive to price levels and the size of the bid-ask spread. Two sets of price-stratified results are reported; (1) test sample one (TS1) and (2) test sample two (TS2). Next Day returns (%RET) are also reported along with the total number of observations (N). Analysis of the TS1 results is followed by an analysis of the TS2 results.

When the last trade price is equal to or less than the closing bid price, next day returns (measured close-to-close) are positive for all deciles, and statistically significant for the first eight deciles. The (t+1) closing spreads are larger and exhibit a near monotone increase in the percentage change from the lowest to the highest price decile. All next day spread change magnitudes are statistically significant and positive. The change in spread is primarily the result of a drop in the bid-side quote. These results are exhibited in Table 6.8.A.1. (t-statistics in parentheses.)

Table 6.8.A.1: TS1 Next Day Changes
Close =< Bid

Dec	%CHG S	%CHG A	%CHG B	%RET	N
1	21.090	1.702	-19.389	1.111	1900
	(19.0)	(0.72)	(8.08)	(14.2)	1900
2	26.142	6.007	-20.135	0.546	1722
	(19.5)	(1.73)	(5.76)	(10.0)	1722
3	33.555	11.526	-22.029	0.480	1469
	(20.9)	(2.65)	(5.17)	(8.76)	1469
4	29.712	11.867	-17.845	0.472	1359
	(17.7)	(2.49)	(3.79)	(9.08)	1359
5	32.229	1.676	-30.552	0.333	1466
	(20.5)	(0.34)	(6.23)	(6.89)	1466
6	37.589	1.862	-35.727	0.269	1219
	(19.0)	(0.26)	(4.99)	(4.84)	1219
7	37.158	1.147	-36.011	0.270	1065
	(18.8)	(0.14)	(4.50)	(4.67)	1065
8	39.496	-6.685	-46.181	0.136	1240
	(19.6)	(0.75)	(5.25)	(2.68)	1240
9	43.557	-24.408	-67.965	0.054	1063
	(19.5)	(1.97)	(5.47)	(0.88)	1063
10	43.503	-8.481	-51.984	0.089	1205
	(17.4)	(0.63)	(3.91)	(1.94)	1205

The larger percentage changes in the upper deciles is due to the larger absolute spread for stocks trading at higher prices; typically 3/8 of a point. The largest percentage change in the bid-ask spread results from a change in the bid. Changes on the ask-side are insignificantly different from zero in most deciles. These results reflect the expected changes in the bid-ask spread/prices for markets influenced by specialist activity and/or the limit order book. If the last trade of the day results in the execution (from the limit-order book) of a limit order (to buy), we would expect an increase in the spread on average. Recall that the "market" is defined as the highest unexercised offer to buy (bid) and the lowest unexercised offer to sell (ask) as reflected in the specialist's limit-order book. The average magnitude of the change would depend on the depth of the orders awaiting execution from the specialist' limit order book. An earlier study by Neiderhofer and Osborne (1966) reported clustering of limit orders at whole numbers followed by halves, quarters, and odd eighths. The nonuniform clustering produced nonrandom effects in stock price motion. The results reported in this study may well reflect the effects of nonrandom distributions on the nonrandom outcomes of last trade prices relative to the closing spread/price.

When stocks close inside the bid-ask spread, next day returns are typically and significantly negative for all deciles. The (t+1) closing spreads are smaller and exhibit a near monotone decrease in percentage change from the lowest to the highest price decile. These results are shown in Table 6.8.A.2 (p. 124)

All spread changes are significantly different from zero. Changes in the ask quote are typically negative and significant in all ten deciles. Changes in the bid quotes are smaller in magnitude and are positive for the first four deciles and negative for the last six. The bid-quote changes in the first and last two deciles are significant.

Table 6.8.A.2: TS1 Next Day Changes
Bid < Close < Ask

Dec	%CHG S	%CHG A	%CHG B	%RET C	N
1	-23.537	-14.808	8.729	-0.339	1144
	(25.6)	(7.51)	(4.50)	(3.23)	1144
2	-18.258	-10.501	7.757	-0.138	1743
	(23.6)	(4.68)	(3.48)	(2.18)	1743
3	-15.756	-12.819	2.937	-0.156	2014
	(22.1)	(5.60)	(1.28)	(2.91)	2014
4	-13.653	-10.743	2.911	-0.106	1965
	(18.2)	(4.16)	(1.12)	(2.17)	1965
5	-13.356	-13.822	-0.466	-0.147	2332
	(19.1)	(5.10)	(0.17)	(3.31)	2332
6	-11.441	-14.121	-2.679	-0.134	2522
	(17.6)	(4.85)	(0.93)	(3.18)	2522
7	-10.468	-19.652	-9.184	-0.192	2250
	(14.2)	(6.18)	(2.87)	(4.63)	2250
8	-10.565	-16.346	-5.781	-0.125	2713
	(15.5)	(4.97)	(1.73)	(3.41)	2713
9	-10.266	-20.135	-9.869	-0.150	2679
	(15.7)	(5.27)	(2.57)	(4.10)	2679
10	-9.934	-25.333	-15.399	-0.143	2915
	(14.4)	(5.56)	(3.38)	(4.67)	2915

The observed decrease in the spread may reflect efforts by the specialist to limit competition from other traders or from public traders attempting to use attractively placed limit orders: the use of limit-orders avails the best strategy available to a public trader who desires to narrow the spread and obtain a better execution price. The significant change is a decline in the ask-side quote. This may reflect the general bearish behavior of the market during the period covered by TS1.

When stocks close at a price equal to or greater than the closing ask price, next day returns are significantly negative for all deciles. The (t+1) closing spreads are significantly larger and exhibit a near monotone in the percentage change from the lowest to the highest price deciles. Table 6.8A.3 exhibits these results. The largest percentage change occurs on the ask side (the ask quote is higher) for the first five deciles and on the bid side (it is lower) for the last five deciles. All bid-side changes are negative and significant.

Table 6.8.A.3: TS1 Next Day Changes
Close => Ask

Dec	%CHG S	%CHG A	%CHG B	%RET C	N
1	22.297	15.133	-7.164	-1.591	1261
	16.151	4.483	-2.101	-14.661	1261
2	36.044	19.116	-16.928	-0.705	1168
	16.851	3.821	-3.062	-9.902	1168
3	35.604	22.266	-13.338	-0.543	1109
	18.556	3.963	-2.382	-7.346	1109
4	38.680	14.171	-24.509	-0.574	1022
	18.433	2.246	-3.777	-9.563	1022
5	39.288	22.222	-17.066	-0.456	1163
	19.186	3.504	-2.669	-7.799	1163
6	41.879	9.578	-32.301	-0.506	933
	19.800	1.121	-3.761	-7.802	933
7	42.761	4.366	-38.394	-0.522	785
	17.457	0.393	-3.426	-6.617	785
8	40.617	15.345	-25.271	-0.347	1008
	19.279	1.435	-2.337	-5.785	1008
9	39.122	-36.430	-75.551	-0.521	932
	18.075	-2.697	-5.536	-7.884	932
10	40.831	11.331	-29.500	-0.276	1128
	18.999	0.763	-1.984	-5.338	1128

We would expect that the ask-side quote would increase in the absence of other effects. These results may be ascribed to the general decline of the market during the period under observation. The average change in the spread is consistent with the operation of the specialist's limit order book and may also reflect the effects of price-clustering reported by Neiderhofer (1965). Also, the magnitudes and monotonicity of the changes are quite similar to those resulting from bid-side closes.

The behavior observed in TS1 suggests that next day regularities decline in relative strength as prices (and spreads) get larger. The magnitudes of all next day returns are insufficient for trading profits after transaction costs are considered. The regularity of this behavior is, however, anomalous to the random walk hypothesis.

Results for TS2 are similar to those in TS1. They are exhibited in Tables 6.8.B.1, 6.8.B.2, and 6.8.B.3. When stocks close at or below the closing bid price, next day returns are positive and significant in all but the last two deciles. Spreads are significantly larger and the percentage change in the spread increases in a monotone fashion similar to the TS1 result.

Table 6.8.B.1: TS2 Next Day Changes
Close <= Bid

Dec	%CHG S	%CHG A	%CHG B	%RET C	N
1	24.133	17.627	-6.507	1.515	1757
	(18.7)	(4.39)	(1.63)	(15.2)	1757
2	28.468	25.877	-2.591	0.838	1556
	(18.7)	(4.42)	(0.45)	(10.6)	1556
3	32.303	20.287	-12.016	0.615	1850
	(22.0)	(4.09)	(2.44)	(11.5)	1850
4	37.834	32.375	-5.473	0.601	1157
	(19.1)	(4.36)	(0.73)	(8.92)	1157
5	35.944	30.997	-4.947	0.556	1545
	(20.5)	(4.46)	(0.71)	(9.60)	1545
6	35.587	4.350	-31.237	0.321	1409
	(20.1)	(0.49)	(3.52)	(5.13)	1409
7	35.670	14.525	-21.187	0.348	1191
	(20.1)	(1.32)	(1.93)	(5.25)	1191
8	38.961	23.133	-15.832	0.368	1145
	(19.2)	(1.96)	(1.34)	(5.69)	1145
9	39.955	46.092	6.091	0.407	1071
	(19.8)	(3.066	(0.41)	(5.90)	1071
10	45.312	59.929	14.621	0.326	1041
	(17.5)	(2.56)	(0.63)	(4.80)	1041

Table 6.8.B.2: TS2 Next Day Changes
Bid < Close < Ask

Dec	%CHG S	%CHG A	%CHG B	%RET C	N
1	-23.147	-9.300	13.847	0.060	1332
	(27.6)	(3.91)	5.779	(0.59)	1332
2	-17.047	-1.113	15.932	0.115	1764
	(21.2)	(3.39)	5.536	(1.61)	1764
3	-14.818	4.928	19.740	0.201	2572
	(23.3)	(1.79)	7.183	(3.91)	2572
4	-13.731	4.622	18.354	0.202	1990
	(18.9)	(1.41)	5.554	(3.66)	1990
5	-12.840	3.175	16.012	0.124	2618
	(20.8)	(0.97)	4.863	(2.53)	2618
6	-10.387	4.136	14.515	0.119	2931
	(16.9)	(1.22)	4.263	(2.75)	2931
7	-10.804	9.707	20.497	0.162	2713
	(12.7)	(2.43)	5.216	(3.67)	2713
8	-8.250	5.515	13.746	0.105	2738
	(4.07)	(1.20)	3.059	(2.32)	2738
9	-8.149	0.765	8.882	0.049	3093
	(13.9)	(0.16)	1.889	(1.29)	3093
10	-7.762	5.743	13.375	0.058	2871
	(11.0)	(0.86)	1.997	(1.50)	2871

Table 6.8.B.3: TS2 Next Day Changes
Close => Ask

Dec	%CHG S	%CHG A	%CHG B	%RET C	N
1	25.974	44.534	18.557	-0.650	1489
	(17.8)	(9.51)	(3.99)	(5.90)	1489
2	33.371	44.954	11.583	-0.245	1300
	(18.7)	(6.98)	(1.77)	(2.88)	1300
3	34.148	36.181	2.023	-0.304	1668
	(20.2)	(6.52)	(0.36)	(5.15)	1668
4	36.040	45.473	9.433	-0.254	1053
	(17.9)	(5.31)	(1.11)	(3.57)	1053
5	38.159	46.904	8.741	-0.205	1297
	(19.8)	(5.52)	(1.03)	(3.10)	1297
6	37.312	49.136	11.575	-0.203	1204
	(19.1)	(4.77)	(1.13)	(2.82)	1204
7	36.839	37.078	0.238	-0.236	1052
	(18.4)	(3.35)	(0.02)	(3.58)	1052
8	40.878	42.386	1.477	-0.194	1073
	(19.2)	(3.27)	(0.11)	(2.79)	1073
9	37.059	22.124	-15.007	-0.247	1044
	(18.3)	(1.48)	(1.01)	(3.77)	1044
10	39.721	22.108	-17.782	-0.251	1086
	1(7.8)	(1.01)	(0.82)	(3.94)	1086

When stocks close on the ask side or above, next day returns are negative and significant for all deciles. When stocks close inside the bid-ask spread, next day spreads were significantly smaller.

The principal differences between the TS1 and TS2 are related to which side of the spread changes the most. TS2 bid-side closes were typically accompanied by a significant increase in the next day ask quote for eight of the ten deciles. This was also the situation when stocks closed on the ask side. When stocks closed inside the bid-ask spread, next day returns were positive and significant in six of the ten deciles. These particular results are exactly opposite to the behavior observed in TS1. A plausible explanation for these differences is most likely related to the underlying trends in the stock market. The expected direction and relative magnitudes of next day changes are significantly influenced by the trend of the market.

The results reported herein complement those reported earlier by Neiderhofer and Osborne (1966). Their study reported the regularity of intra-daily price-reversals for sequential transactions and nonrandom limit-order price clustering. The results reported here differ in two important aspects. First, earlier studies did not examine the relationship of serial price dependencies in relation to bid-ask spreads. Second, those studies focused on intra-daily trading patterns. The results reported in this study indicate a more significant regularity in the behavior of next day price changes given today's closing price relative to the closing bid-ask spread. Caution is warranted in interpreting the implications of these results due to the relatively small time samples used in the study. However, the similarity of next day behavior of the variables in both samples suggests that this behavior is more than just the artifact of a particular sample.

The results reported herein, however, cast a shadow on recent efforts by Roll (1984), Harris (1985), and others, to measure the effective bid-ask spread. Central to their measurement scheme are two assumptions. First, that most trading takes place inside the bid-ask spread. Hence their assertion that the uninformed trader actual pays a smaller "effective" spread. Second, they assume that price fluctuations within the bid-ask spread are random. The effective result is that the effective spread may be measured as $2\sqrt{-\text{cov}}$, the relationship hypothesized by Roll (1984) as defining the value of the effective spread. The results presented in Tables 6.8.A.1 through 6.8.B.3 indicate significant nonrandom regularities in price behavior from day to day. Moreover, the results are nonuniform in magnitude across different price levels and market trends. Many trades do occur at the bid or the ask as well as inside the quoted spread. Also, there is evidence presented in the current research to indicate that even when trades occur inside the bid-ask spread, there is no regularity of expectation that they occur at the exact center of the spread. It is possible that the results presented in this research may cause a re-evaluation of theories and methods being developed to measure "effective" spreads paid by uninformed traders.

In general, the results reported herein provide additional information on the nature of serial price dependencies at the microstructure level. The significant regularity of next day returns with respect to sign and magnitude would seem to suggest a potentially exploitable strategy. We will explore such possibilities when we examine the effects of different price constructs on the computation of a popular market index. Also, these results may provide some insight into specialist behavior.

6.7 The DJIA under Alternative Price Assumptions

This study seeks to determine the sensitivity of market indexes to alternative specifications of closing prices. The Dow Jones Industrial Average (DJIA) has been selected for this investigation. The DJIA is computed using four different price specifications: Close, Bid, Ask, and the mean of the closing bid and ask price quotes (the "true" price construct). Tables 6.9.A (TS1) and 6.9.B (TS2) display the values of the DJIA index using closing prices (DJIA-C) and the mean of the closing bid and ask prices (DJIA-M). Equation (6.4) is used to calculate the daily value of the index:

$$DJIA = \Sigma P_n / 1.314 \qquad \text{for } n = 1,2,,,30 \qquad (6.4)$$

Where: P_n = closing price for each DJIA component stock
1.314 = DJIA divisor

The computed values of the index using closing prices and the mean of the closing bid and ask quotes are statistically identical. The same relationship is true for the index computed with closing bid or ask prices. As expected, the DJIA index constructed from closing ask prices is slightly higher, the DJIA index with closing bid prices slightly lower than the traditionally constructed index (DJIA-C). Pairwise correlations correlation coefficients are all in the .97 to .99 range. We conclude that the DJIA is insensitive to the closing price specification used in its construction.

TABLE 6.9.A: DJIA Alternative Price Assumptions
Closing Distributions and Momentum Index

Test Sample One

Day	(1) DJIA-C	(2) DJIA-M	(3) C=B	(4) INS	(5) C=A	(6) MI
1	890.22	890.22	23%	47%	30%	0.533
2	882.61	883.28	50%	27%	23%	0.361
3	883.85	883.70	27%	50%	23%	0.494
4	892.69	892.79	33%	43%	23%	0.461
5	886.99	886.80	40%	17%	43%	0.525
6	881.75	881.28	17%	47%	37%	0.589
7	888.22	888.22	30%	40%	30%	0.500
8	892.03	892.17	33%	40%	27%	0.467
9	886.51	886.84	43%	33%	23%	0.400
10	871.48	872.15	60%	23%	17%	0.278
11	875.95	875.33	27%	33%	40%	0.572
12	868.72	869.20	37%	30%	30%	0.428
13	870.53	870.62	43%	23%	33%	0.450
14	875.00	875.62	37%	37%	17%	0.356
15	873.10	873.72	53%	30%	17%	0.306
16	871.96	871.77	30%	27%	43%	0.572
17	869.67	869.58	30%	37%	33%	0.519
18	873.48	873.48	23%	37%	37%	0.489
19	870.34	870.53	40%	33%	27%	0.428
20	868.25	868.39	37%	23%	40%	0.506
21	873.10	873.72	47%	30%	23%	0.367
22	875.00	874.90	20%	50%	30%	0.544
23	882.52	882.42	33%	27%	40%	0.522
24	865.30	866.01	50%	40%	10%	0.311
25	861.02	861.44	43%	30%	27%	0.417
26	861.78	861.73	30%	40%	30%	0.500
27	866.53	865.92	37%	17%	43%	0.617
28	850.46	850.74	37%	23%	37%	0.461
29	847.70	843.03	33%	40%	27%	0.456
30	838.95	838.80	27%	37%	37%	0.558
31	842.28	842.47	47%	17%	37%	0.450
32	847.60	847.27	33%	23%	43%	0.561
33	855.12	854.12	20%	40%	40%	0.609
34	847.41	847.41	40%	20%	40%	0.494
35	845.89	845.84	30%	33%	37%	0.528
36	848.27	848.89	50%	30%	20%	0.344
37	845.03	845.51	40%	33%	27%	0.433
38	842.75	842.51	27%	50%	23%	0.507
39	841.51	841.13	30%	23%	47%	0.594
40	842.66	843.32	53%	27%	20%	0.333
41	864.25	862.87	13%	37%	47%	0.911
42	871.10	870.34	3%	47%	47%	0.700
Summary Statistics						
Mean	866.42	866.34	35%	33%	32%	0.487
SDev	15.87	16.04	11%	9%	9%	0.114

Table 6.9.B: DJIA Alternative Price Assumptions
Closing Distributions and Momentum Index

Test Sample Two

	(1)	(2)	(3)	(4)	(5)	(6)
DAY	DJIA-C	DJIA-M	C=B	INS	C=A	MI
1	1021.77	1022.35	33%	37%	30%	0.385
2	1024.54	1024.59	37%	33%	30%	0.490
3	1022.44	1022.39	40%	30%	30%	0.510
4	1046.70	1046.27	23%	37%	40%	0.582
5	1047.56	1047.60	27%	43%	30%	0.491
6	1038.01	1038.29	30%	50%	20%	0.452
7	1022.54	1022.11	27%	47%	27%	0.569
8	1015.47	1015.76	43%	33%	23%	0.452
9	1021.20	1021.06	33%	40%	27%	0.527
10	1007.54	1008.02	47%	27%	27%	0.404
11	992.65	991.50	33%	17%	50%	0.761
12	987.20	987.11	27%	40%	33%	0.521
13	1004.78	1005.54	43%	33%	23%	0.357
14	999.90	999.52	13%	53%	33%	0.571
15	1020.05	1019.72	27%	40%	33%	0.557
16	1027.79	1027.69	23%	50%	27%	0.517
17	1038.68	1038.91	40%	43%	17%	0.456
18	1062.74	1061.88	20%	40%	40%	0.667
19	1051.47	1051.95	40%	30%	30%	0.400
20	1053.19	1053.05	27%	43%	30%	0.524
21	1041.06	1041.68	43%	30%	27%	0.377
22	1039.53	1039.87	37%	33%	30%	0.434
23	1022.36	1021.77	27%	30%	43%	0.842
24	1041.54	1040.87	10%	37%	53%	0.635
25	1041.16	1040.63	27%	27%	47%	0.612
26	1070.00	1070.04	37%	33%	30%	0.491
27	1074.87	1074.87	27%	47%	27%	0.500
28	1090.15	1089.62	27%	33%	40%	0.600
29	1081.46	1080.84	23%	30%	47%	0.633
30	1080.69	1080.98	37%	37%	27%	0.437
31	1071.05	1071.29	47%	30%	23%	0.447
32	1077.54	1077.30	30%	30%	40%	0.561
33	1080.79	1080.88	43%	23%	33%	0.478
34	1077.06	1077.68	47%	37%	17%	0.386
35	1069.04	1068.71	33%	37%	30%	0.569
36	1072.00	1072.34	43%	23%	33%	0.429
37	1057.30	1057.44	23%	47%	30%	0.471
38	1033.23	1033.66	33%	43%	23%	0.426
39	1043.64	1043.83	33%	37%	30%	0.463
40	1039.63	1040.11	30%	40%	30%	0.407
41	1063.84	1062.41	13%	33%	53%	0.763
42	1065.80	1064.89	20%	27%	53%	0.686
43	1075.44	1075.34	27%	30%	43%	0.518

Summary Statistics

Mean	1044.54	1044.47	31%	36%	33%	0.520
SDev	26.46	26.43	9%	8%	9%	0.109

Columns (3), (4), and (5) in Tables 6.9.A and 6.9.B capture the distribution percentages of the DJIA stocks' closing prices in relation to the closing bid-ask price spreads. Not shown in Tables 6.9.A or 6.9.B are the small number of stocks closing outside the closing bid-ask spread. The incidence of DJIA stocks closing outside the bid-ask range occurred less than 10 times per sample. This result is not surprising as the DJIA issues are very actively traded. Average daily (NYSE) trading volume during the TS1 period was in excess of 140,000 shares.

Earlier we described the regularity of next day price moves when today's closing prices relative to the closing bid and ask price quotes are known. We investigate if a meaningful relationship exists in where the DJIA stocks close in relation the closing bid and ask price quotes and next day moves in the DJIA.

To capture the combined effects of the closing price distributions we utilize the Momentum Index (MI). Figures 6.1.A and 6.1.B plot the daily values of the momentum index (MI) as well as the trend of the DJIA over the TS1 and TS2 periods, respectively. Column (6) in tables 6.8.A and 6.8.B list the daily values of the MI. In effect, the MI summarizes the closing distribution data in columns (3) through (5) in a more meaningful format. The mean value for the DJIA component stocks for TS1 is .487, reflecting the general downward trend of the market and the very slight dominance of bid-side closes. The TS1 mean MI value is insignificantly different from an expected value of .500 (t = -.625). The mean value for TS2 is .520 and the t-value = 1.005.

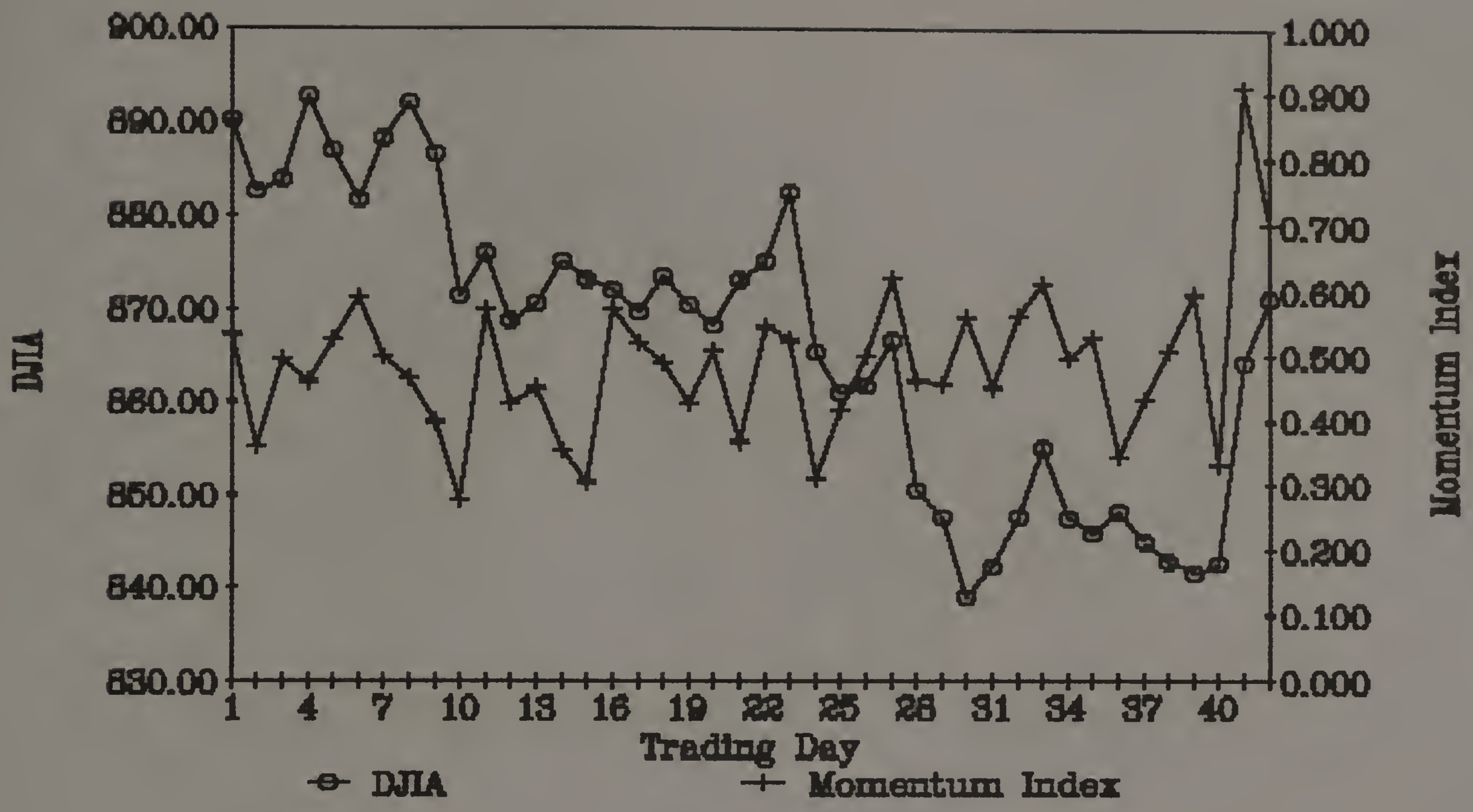

Figure 6.1.A. TS1 DJIA versus Momentum Index. Values plotted are for the period December 1, 1981 through January 29, 1982.

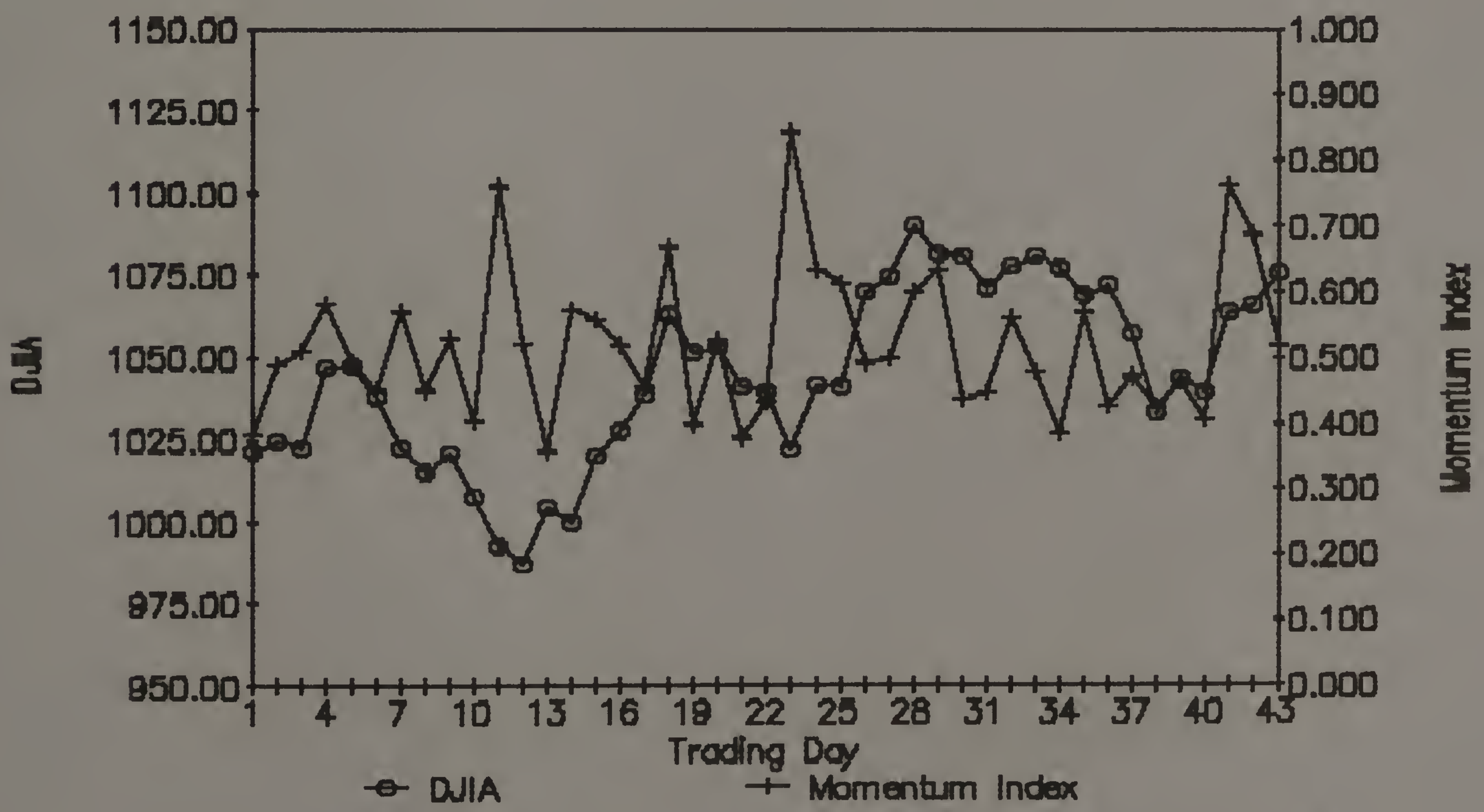

Figure 6.1.B. TS2 DJIA versus Momentum Index. Values plotted are for the period December 1, 1982 through January 31, 1983.

We next test the correlations of time t's MI and time t+1's DJIA. If the closing distributions are useful in predicting next day returns, then we should observe a positive correlation between MI_t and DJIA-C_{t+1}. The calculated correlation coefficients for MI_t and DJIA-C_{t+1} for TS1 and TS2 are .0624 and .0965, respectively. Correlations for MI_t and DJIA-M_{t+1} were .0612 (TS1) and .0962 (TS2). The signs are positive as expected, but the MI appears to offer limited knowledge in forecasting the DJIA in either of the two specifications tested. We can explain less than 1% of the variation in the day (t+1)'s DJIA from the information contained in day (t)'s momentum index. A probable explanation for the weak correlations may be found in the effects of portfolio diversification. As more issues are added to a portfolio, the strong correlations for individual stocks described in the previous section are attenuated by the averaging out of bid- and ask-side closes.

6.8 Security Risk Measures under Alternative Assumptions

We are interested in determining if the use of alternative return measurement specifications reduce the degree of errors in estimated betas when using the market model (see equation 3.12). Herein betas are estimated using returns measured close-to-close (Beta-C) and returns measured using the mean of the closing bid and ask spread (Beta-M). The results are reported for price-stratified data similar to that used in prior sections. All returns are computed using equation (6.7):

$$R_i = [\ (P_t + D_t) \ / \ P_{t-1}\ ] - 1 \qquad (6.7)$$

Tables 6.10.A and 6.10.B present the results of estimating beta using the market model for each of the return generating model assumptions. In each case the "market" portfolio consists of all 1134 issues in TS1 and 1205 issues in TS2. Two sets of cross-sectional averages of all stocks in each decile are examined: the average beta estimate for each price specification (Beta-C, Beta-M) and the average standard error of the estimate (SEE-C, SEE-M). The differences between the means for each set of paired estimates are tested statistically and the results are reported in columns (3) and (6).

Table 6.10.A: Market Model Betas & Alternative Price Definitions
Cross-sectional Means for TS1 (Dec81-Jan82)

Dec	(1) Beta-C	(2) Beta-M	(3) t-test	(4) SEE-C	(5) SEE-M	(6) t-test
1	1.053	0.991	0.518	0.034	0.029	3.148
2	0.887	0.871	0.180	0.022	0.021	1.345
3	0.950	0.937	0.152	0.020	0.019	1.500
4	0.899	0.879	0.198	0.018	0.017	0.161
5	0.936	0.933	0.028	0.017	0.017	0.896
6	1.089	1.104	-0.158	0.018	0.017	0.534
7	0.962	0.984	-0.214	0.017	0.016	0.695
8	0.986	1.012	-0.313	0.016	0.016	0.380
9	1.183	1.201	-0.212	0.016	0.016	0.500
10	1.046	1.070	-0.362	0.013	0.013	0.339

The results reported in Table 6.10.A, column (3), indicate that there are no significant differences, on average, in the magnitudes of the beta estimates using the two closing price specifications for any of the price stratified deciles. The general tendency is for lower price stocks to have slightly lower betas and higher price stocks to have slightly higher betas when returns are computed from expected closing prices. Column (6) indicates that statistically significant increases in estimation efficiencies are achieved for the lowest price stock decile. The efficiency gains decrease as prices get larger.

Similar results are reported in TS2 (Table 6.10.B). Mean estimated betas are slightly lower when returns computed from expected closing prices are utilized instead of observed closing prices. The differences in the two sets of beta estimates are insignificantly different from zero. Obvious increases in ex post prediction efficiency are evident in the lowest price decile and decreasing rapidly as prices get larger.

Table 6.10.B: Market Model Betas & Alternative Price Definitions
Cross-sectional Means for TS2 (Dec82-Jan83)

Dec	(1) Beta-C	(2) Beta-M	(3) t-test	(4) SEE-C	(5) SEE-M	(6) t-test
1	1.214	1.179	0.325	0.039	0.035	2.638
2	1.077	1.066	0.110	0.027	0.026	1.047
3	0.897	0.899	-0.031	0.022	0.021	1.264
4	0.922	0.911	0.144	0.021	0.020	0.138
5	0.929	0.935	-0.081	0.021	0.020	0.809
6	0.969	0.978	-0.116	0.021	0.020	0.584
7	0.951	0.963	-0.152	0.020	0.019	0.486
8	1.029	1.032	-0.050	0.020	0.019	0.193
9	1.005	1.009	-0.075	0.018	0.018	0.499
10	1.052	1.063	-0.199	0.018	0.018	0.298

The increase in estimation efficiency for the lowest priced stocks when returns are computed using the mean of the closing bid-ask spread suggest a potential source of low-price or size effects reported in the anomalies literature. Additional testing with larger samples of closing bid-ask data may be necessary to determine fully the extent of any efficiency increases. This type of data may also prove useful in helping to explain low-price effects.

CHAPTER 7

SUMMARY AND CONCLUSIONS

This chapter begins with a review of the objectives underlying the current research effort and summarizes its findings. The review is followed by a discussion of the insights acquired into the structural relationships between theoretical price constructs and observed prices, theoretical returns and risk, and observed returns and risk measurements. The implications of those observations are also discussed. A note on the limitations of the current study completes the discussion and review. The chapter closes with a delineation of potential areas for further research.

7.1 Review of Objectives and Results

The following issues were investigated in this study:

1. How accurately do observed closing prices approximate the theoretically expected closing prices?

2. How accurately do returns computed from closing prices approximate returns computed from expected closing prices?

3. To what extent are findings of empirical anomalies the result of a misspecification of the returns generating process?

4. How sensitive are measures of relative risk (beta) when alternative price constructs are used?

In addition to the issues listed above, an investigation was conducted on the nature of the serial correlational behavior of sequential stock prices.

To evaluate the first issue, two stock price series were compared. The first price series was composed of the market closing prices for all stocks in the test and the verification samples for the time periods under observation. These prices were treated as approximations for expected closing prices. The second price series was constructed from the mean of the closing bid and ask price quotes for all stocks in the samples. The second set of prices should be exactly equal to expected closing prices in an efficient market. Efficient market theory suggests that the means of the two price series should be equal. The empirical results based on the comparison of the two prices series from two separate samples indicate that:

1. The means of the two price series are significantly different and the average magnitude of the difference is approximately equal to one cent.

2. The magnitude and sign of the of the difference is sensitive to the effects of trends in closing prices. Bear trends produce negative biases, bull trends positive biases.

3. Estimation errors are sensitive to price levels. The average magnitude of the error declines as prices get very large.

The second issue was evaluated by computing two sets of returns. The first set of returns was computed utilizing observed closing prices and is typical of the method used to compute security returns. The second set was computed using the mean of the closing bid and ask prices. Returns computed using the latter series approximate true returns. A comparison of the two return series indicates that:

1. Observed returns are typically less negative (more positive) than true returns and are slightly more volatile.

2. The magnitude of the return estimation errors are non-linear in price. The estimation error is positive and random.

3. No significant differences are observed between the two return series for the combined samples.

The third issue dealt with the persistence of empirical anomalies when alternative price and return generating process specifications are considered. Returns were computed using three specifications for prices; close-to-close, ask-to-bid (market order), and bid-to-ask (limit-order). A comparison of the three sets of returns indicates that:

1. The persistence of the low price anomaly is dependent upon the method used to measure returns and the characteristics of the sample. Small low price effects were found in the test sample; much larger and more significant effects in the verification sample.

2. The evidence indicates that the weekend effect may be sensitive to the number of stocks going ex-dividend on Mondays compared to Fridays. With very few exceptions, no weekend effect is observed in sub-samples of stocks which did not go ex-dividend on Mondays.

3. The weekend effect is inconsistent across price ranges. Less than half of all deciles displayed strong weekend effects; three displayed no weekend effect and these three deciles included the lowest and highest price deciles.

4. Samples containing substantial numbers of ex-dividend stocks result in significant weekend effects.

5. The January effect appears to be more complex than a simple end-of-year or tax-induced phenomenon. It also appears to involve a broader spectrum of stocks.

The last issue investigated required the estimation of relative risk (beta) measures using closing prices and expected closing prices (mean of the closing bid and ask price quotes). The results of this study indicate that:

1. Relative risk estimates are not statistically different when expected closing prices are used to compute returns rather than using observed closing prices.

2. The ex-post standard error of the estimate improves marginally when expected closing price equivalents are utilized to estimate relative risk.

An investigation related to the fourth issue examined the nature of serial correlations observed in sequential prices. The objective of these tests was to determine if movements in a market index could be forecasted given knowledge of today's closing prices relative to the closing bid-ask price quotes. The principal question is whether a relationship exists between today's closing price and tomorrow's expected return. The results of this investigation reveal that:

1. Day (t+1) returns are systematically related to where stocks close day(t). Closes at the ask and inside the closing bid-ask spread are typically followed by significantly negative returns the next trading day. Closes at the bid are typically followed by positive returns the next trading day.

2. Close-to-close returns are systematically greater in magnitude (positively or negatively) than close-to-open returns.

3. The magnitude of the day(t+1) returns are inversely related to price; the lower the price, the greater the magnitude.

4. The magnitude of next day returns are insufficient for one to earn trading profits when brokerage and spread costs are considered.

5. The closing price location of stocks are significantly related to changes in the spread. Bid- and ask-side closes are typically followed by increases in the spread. Stocks which close inside the bid-ask spread experience significantly smaller next-day spreads.

6. The magnitude of the change in spread is related to price for bid-side closes. The larger the price, the greater the magnitude of next day spread changes. When stocks close inside the bid-ask spread, the relationship is inverse; the larger the price, the smaller the spread change. Ask-side closes generally have smaller changes.

7.2 Insights and Implications

Are prior tests of market efficiency and the asset pricing models affected by the specification of price structures and return measurement models? The general results of this study suggest that significant problems exist with the results of all general market studies which rely on closing prices to measure returns. When closing prices are solely utilized to compute holding period returns, substantial biases are induced. The biases introduced result from the exclusion of market trading behavior from efficient market theory. Efficient market theory may be reasonably described as a normative theory. When return computation methods incorporate market trading behavior, substantially different results obtain. The specification of expected closing prices by some researchers is viewed as an attempt to minimize price measurement errors. A more positive view requires that the prices most likely to be obtained by a public trader are the prices which ought to be used to compute returns.

The most significant implication of this study pertains to anomalous findings in tests of market efficiency. When market trading patterns are incorporated in return measurement models, substantially different results are obtained. The significance of the low price effect is largely a function of the assumptions used to specify the price structures utilized in computing returns. Moreover, the presence and magnitude of low price effects are related to the methodology used to measure portfolio returns. Finally, research results reporting an unstable low price effect or an unstable size effect may be affected by the magnitudes of the market trends contained in the research sample. Blume and Stambaugh (1983), Keim (1983), et al., frequently subdivide their samples into smaller subsamples and examine the strength of the anomalies in each subsample. A frequent observation is that these effects are unstable over time. The relatively small sample used in the current investigation suggests that bear markets appear to produce the smallest low price effects; bull markets the largest effects. Additional research is indicated with larger samples of bid-ask data.

In the case of the weekend effect, a substantial explanation for the anomaly may stem from poor controls for ex-dividend effects in prior studies. The tendency for large numbers of stocks to go ex-dividend on Mondays in contrast to Fridays appears to be the principal cause of the evidence for a weekend effect. Also, the effect is not uniform across all price levels. It is statistically absent in the lowest and highest price deciles.

7.2.1 Closing Prices and Returns

Efficient market theory acknowledges the variation of prices over time as prices adjust to new information. In general, the mean of observed closing prices should be equal to the expected closing prices. In an efficient market, the expected closing price should be equal to the mean of the bid and ask prices. The results of this study indicate that, from the point of view of a statistical test for equality of means, the observed and expected means are different. The magnitude of the differences are also sensitive to the underlying market trend. The greater the volatility of the market, the larger the difference. The sign of the difference is dependent upon the bearish or bullish nature of the market: Bear markets produce negative magnitudes, bull markets positive magnitudes. The market trends examined in this study did not produce a difference with a positive sign. The results, however, clearly indicate that the sign and magnitude of the difference is related to the underlying market trend. An unresolved question is why the verification sample momentum indexes tended to indicate averages below .500 for a market in a major bull move. Recent research has suggested that market prices tend to move up toward the end of the trading session. This suggests a potential area for additional research.

7.2.2 Empirical Anomalies and Price Specifications

How sensitive are findings of empirical anomalies to alternative price specifications in the return generating process? The results of this investigation do not provide a definitive answer. Low price effects were found in the test and verification samples for returns measured using closing prices. When market order-based returns are utilized, the effect is insignificant for the bear market sample and substantially significant in the bull market sample. Similar results are found using returns based on limit order executions. A partial explanation may be related to the behavior of the bid-ask spread and the minimum size of the spread for low priced stocks.

Another possible explanation for the different results stems from the implicit assumptions of the normative character of efficient markets theory. The time series average of observed closing prices are very likely equal to expected closing prices for samples covering longer periods of time. But expected closing prices are not likely to be obtained by a public trader using a market order. Executions at the bid or the ask price are more likely, especially for lower priced stocks with narrow dollar spreads and low trading volumes. The immediate result is an increase in specialist participation; stocks are bought at the ask and sold at the bid. Computed returns based on trading patterns are substantially lower than returns computed from closing prices. The general result is an inconsistency between the behavioral implications of efficient market theory and the actual behavior of the market. Most market studies have relied on price data inconsistent with obtainable prices. The results have shown up as anomalous to market efficiency. The general implication of this study is that at least some prior anomalous findings may be artifacts of the misuse of observed closing prices as obtainable prices rather than prices obtainable by public traders using market orders. The implied inefficiency of the market or inadequacy of the asset pricing models are critically tied to the fallacy implicit in positive implementations of a normative theory. The degree to which efficient market tests abstract from the real operation of the market may underlie the anomalous results reported in the literature.

In the case of weekend effects, prior reports of behavior anomalous to the random walk hypothesis failed to control for the incidence of ex-dividend day effects. The results of this study indicate that the effects are related mainly to stocks going ex-dividend. Stocks which do not go ex-dividend on Monday do not exhibit significant negative weekend returns in contrast to Monday-Tuesday returns. Also, the effect is not generalized across all price ranges. It is strongly present in three of the ten deciles and totally absent in three others. The remaining four deciles exhibit varying degrees of weekend effects. The implication of these results is that the effect is sample specific. Samples with large numbers of dividend paying stocks have a high probability of ex-dividend dates falling on Monday. Accordingly, weekend effects are likely to be present. When samples exclude stocks going ex-dividend on Mondays, the effect is essentially absent.

7.2.3 Autocorrelation and the Behavior of Stock Prices

A startling discovery in this research is the additional insight provided by information on the position of the closing price relative to the closing bid-ask spread. Several earlier studies in security market behavior reported the presence of negative serial correlation in sequential price series for individual securities. This study significantly expands those results. Specifically, the next-trading day returns are directly influenced by where stocks close. Also, the magnitude of the next-day returns are strongly and inversely related to price level; lower price stocks tend to have substantially larger relative (percentage) changes than higher priced stocks. These results suggest that a portion of the low price effect may be tied to the autocorrelational properties of sequential stock prices and to statistical artifacts arising from the price level and the magnitude of the change in dollar terms. Also, the mis-estimation of risk does not appear to be the reason for excess returns accruing to the low price stocks. The oscillation of recorded transaction prices between the bid and ask price spread appears to induce higher coefficients of variation (risk) in stock returns. When stock returns are measured using market or limit orders, substantially lower coefficients of variation (risk) are obtained. It would appear that the mis-estimation of risk due to nonsynchronous trading is an insufficient explanation for the size effect. The low price effect is also affected by the relative scales of the change magnitude (in cents) and the average dollar value of the security. Thus, one cent changes result in substantially larger effects for low priced stocks in comparison to higher priced stocks.

7.2.4 Price Specifications and Relative (Beta) Risk

Results reported in this study indicate that a small portion of beta estimation errors arise from the use of observed prices as equivalents for expected closing prices. The magnitudes are small and generally insignificant for the sample examined. A larger sample might yield different results.

Differences in betas estimated from closing prices or expected closing prices do not differ significantly. Marginal improvements in ex-post forecasting efficiency are obtained when expected closing prices are utilized rather than closing prices. This observation is most likely the result of removing the price estimation bias when observed closing prices are utilized instead of expected closing prices. Moreover, the estimation bias is strongest in the lowest price deciles.

7.3 Limitations

In drawing inferences from the empirical results of this study, the limited size and time frame of the samples need to be kept in mind. The underlying trends of the market may have biased the sign and the magnitude of the results reported. Also, the restriction of the sample to NYSE stocks may have attenuated the magnitude of low price effects for close-to-close returns. Finally, the attenuation of the low price effect when returns are measured ask-to-bid may be more pronounced for larger samples of lower priced stocks (such as might be found on the AMEX or OTC) and similar absolute spread characteristics.

Notwithstanding these reservations, the results of this study shed important light on the methods by which normative theories are operationalized. Efficient market theory does not consider the practical aspects of the mechanics of trading in a market dominated in many instances by the market specialist. The strong effects of spreads and limit-order price clustering may underlie findings of anomalous behavior. The regularity of next day price behavior is potentially troublesome. Statistical tests of samples require that the populations from which they are drawn be normally distributed. The evidence presented in this study indicates the existence of stronger regularities than previously thought. Also, these regularities may distort efficient market test results.

The alternative methodologies employed in this study for measuring returns yield substantially less volatile day-to-day returns. The re-specification of the return generating process to reflect the operation of security markets dominated by specialist activity and liquidity costs are suggested as important corrections for analyzing efficient market operation. Specifically, in the absence of Walrasian market structures and strictly continuous trading among a large number of traders, the imposition of liquidity providing agents alters substantially the operationalization of efficient market theory. The effective result is an attenuation of one category of market anomalies; ie., the size effect.

7.4 Extensions

The results of this study suggest at least three major extensions for future research. The first extension would be to examine a larger data set of closing bid and ask prices. This expanded data set would include at least six full years of closing bid and ask prices, closing prices, and trading volumes. In order to prepare such a large data sample in computer readable form, a monthly time horizon would be advisable. Accordingly, 72 days of data would be utilized. The expanded data set would include at least one complete market cycle. This sample would be used to test more fully the biases induced in computed returns when closing prices are utilized to compute returns in preference to expected closing prices. The results of the current study indicate a potentially rich topic for investigation.

A second area for extending the current study relates to risk measures (beta) and market efficiency. The limited time sample used in this study did not permit a viable estimate of beta. The preliminary results indicated some increases in estimation efficiency. Accordingly, a data set with sixty months of historical data would permit estimates of beta utilizing expected closing prices as well as closing prices. The two risk estimates could then be tested on the sixth year of data. This study design would more closely resemble the more typical test of market efficiency using the CAPM.

The third extension is a more detailed examination of bid-ask spread behavior, particularly for low price stocks. The results reported in this investigation indicate a spread magnitude larger than that predicted by regression analysis. A portion of the size effect may be related to the behavior of this variable. The bid-ask spread may also be a missing factor in the asset pricing model.

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