U. S. Department of Commerce, Bureau of Economic Analysis, *National Income and Product Accounts of the United States*, 1929-74.

White, B. B., "Empirical Tests of the Life Cycle Hypothesis," *American Economic Review*, September 1978.

M/D/217

Faculty Working Papers

ANALYSIS OF THE INTERTEMPORAL VARIATION OF DEALER COSTS FOR BLOCK TRANSACTIONS ON THE NEW YORK STOCK EXCHANGE

Frank K. Reilly, Professor, Department of Finance
David J. Wright, Indiana University

#618

College of Commerce and Business Administration
University of Illinois at Urbana-Champaign

FACULTY WORKING PAPERS

College of Commerce and Business Administration

University of Illinois at Urbana-Champaign

October 16, 1979

ANALYSIS OF THE INTERTEMPORAL VARIATION OF DEALER COSTS FOR BLOCK TRANSACTIONS ON THE NEW YORK STOCK EXCHANGE

Frank K. Reilly, Professor, Department of Finance
David J. Wright, Indiana University

#618

Summary:

This study provides a time series analysis of the dealer cost for block transactions on the NYSE using daily data for the period 1972-1977. The results indicate that the basic time series for block concessions for plus and minus tick blocks are not random series. There is a discussion of what variables affect the series and the implications for institutional traders and government agencies.

ANALYSIS OF THE INTERTEMPORAL VARIATION OF DEALER COSTS FOR BLOCK TRANSACTIONS ON THE NEW YORK STOCK EXCHANGE*

David J. Wright
Frank K. Reilly**

INTRODUCTION

Recent innovations in the security market structure have increased the demand for information concerning the economics of security transaction costs. The financial literature has focused on the behavior of the security dealer, because the dealer's price quotations have a significant impact on the cost of transacting. Since the dealer quotes his bid and offer prices away from the perceived equilibrium price, anxious investors incur a dealer cost (or liquidity cost) on their transactions. Earlier studies analyzed the differences in the dealer cost among a cross-section of transactions.[1] In contrast to the previous studies, this investigation adds the dimension of time by examining the time series behavior of dealer costs. Specifically, this study provides a time series analysis of the dealer cost for New York Stock Exchange (NYSE) block transactions. This involves the analysis

---

*The authors acknowledge the comments of Kenneth Carey, James Gentry and Donald Roberts and the use of the computer facilities at the University of Illinois.

**The authors are Assistant Professor of Finance, Indiana University and Professor of Finance, University of Illinois, respectively.

[1] The major studies that used cross-sectional methodology are Harold Demsetz, "The Cost of Transacting," Quarterly Journal of Economics 87 (February 1968): 33-53; Hans R. Stoll, "The Pricing of Security Dealer Services: An Empirical Study of NASDAQ Stocks," Journal of Finance 33 (September 1978): 1153-72; and Seha M. Tinic, "The Economics of Liquidity Services," The Quarterly Journal of Economics 86 (February 1972): 79-93.

of the time series of daily price concessions on block trades during the six year period 1972-1977.

Significance of the Study

An investigation of any systematic intertemporal variation in dealer costs included in block transactions is important for several reasons. The first is that this study adds the dimension of time to the existing dealer behavior theory. The prior research on dealer costs has relied primarily on cross-sectional methods which have been beneficial in recognizing the wide spectrum of dealer transactions costs prevailing at a point in time. On the other hand, these earlier studies do not indicate whether the structure of dealer costs change over time which is the purpose of this study.

In addition, this study contributes additional information on the block securities market, which, because of its sheer size and relative position in the capital market, is important. For the time period 1972 through 1977, an average of 145 blocks were traded per day representing a value of 93,630,000 dollars per day. In relative terms, block trading accounted for 17.4 percent of the NYSE share volume during the same time span. Furthermore, the persistence and growth of the block market is apparent when, in 1977, there was an average of 221 blocks per day and blocks represented 22.4 percent of the NYSE share volume.

Further, the study results should be of assistance to investment managers by integrating a dealer cost timing aspect into their institutional trading policy formation. The institutional investment manager must consider transaction costs before making the decision to exchange assets within his portfolio. The hoped-for advantage of any move must be weighed against the cost of making a decision to trade. Only the trades which can increase performance by more than their transaction cost can be justified. However, the investment manager must first estimate the transaction cost which includes the investor's own direct costs (e.g., communications), the explicit cost of commissions and other fees, and the costs of any unfavorable price movements induced by the dealer costs associated with his transaction.[2] The unfavorable price movement induced by the dealer cost is the most important of the three transaction cost determinants, because the price movement is generally the largest portion of the total transaction cost and, the most unpredictable element. Therefore, prior to the contemplated trade, it is necessary for the investment manager to anticipate the unfavorable price movement linked to the transaction dealer costs and recognize that this element may change over time.

Finally, this study should help in the development of a model of the block trading mechanism which can be used for monitoring security market transaction efficiency over time. The concept of security market transaction efficiency refers to the market's capability to provide a quick security exchange with transaction costs as low as possible, given the cost of providing the services.[3] The concept can

---

[2] U.S. Congress, House, Institutional Investor Study Report of the Securities and Exchange Commission, H. Doc. 92-64, 92nd Cong., 1st sess., 1971, p. 1836.

[3] Richard R. West, "On the Difference Between Internal and External Market Efficiency," Financial Analysts Journal 28 (November-December 1975): 30-34.

be usefully applied to an examination of block trading. Some market observers have claimed that the large price impact linked to a block trade implies market transaction inefficiency. Their assessment is correct only if the large impact did not reflect a genuine difference in justifiable dealer costs for blocks. But, if the large price impact simply reflects high dealer costs for blocks, then the size of the price impacts do not, in themselves, imply transaction inefficiencies. Previous studies have examined the difference between the block trade price impacts and price changes in the non-block market. Alternatively, this study considers transaction efficiency within the block market and examines any difference in the treatment of blocks separated by time.

Outline of Study

The first section discusses dealer services including the factors that influence the demand for these services and the cost of these services. The second section contains a discussion of the prior studies that examined the determinants of dealer spreads for normal transactions and some early work concerned with block trade concessions. In section three we consider the characteristics of the block transaction market including a description of the block price reaction (BPR) indices which reflect the dealer costs for block transactions. Section four contains the basic time series analysis of the BPR indices and an analysis of other variables that influence the series systematic component. In section five and six the analysis of time domain models and frequency domain models are presented and discussed. Section seven contains a summary, conclusion, and a discussion of the implication of the results for those concerned with characteristics of the block trading market.

DEALER SERVICES

Demand for Dealer Services

In conducting economic affairs within the security market arena, there is often a considerable advantage in being able to quickly exchange one asset for another. A market that facilitates a quick security exchange is characterized by purchase orders and sell orders which arrive in different share sizes at different times during any given trading session. Since there may not be a matching purchase and well order at the same moment, a continuous market requires mechanisms for linking orders. The main cog in the mechanism is the dealer who stands ready to trade for his own account and thereby provides market participants the convenience of being able to exchange securities immediately.

Investors would not need the dealer's services if there were perfect synchronization between buy and sell orders. If offsetting orders were always in perfect balance, investors would instantly execute their transactions at the equilibrium price. Accordingly, the transaction price would change only in response to changes in the security's inherent value. In contrast, real markets are described by temporary imbalances between buy and sell orders which create temporary excess demand or excess supply at the equilibrium price. Investors can still obtain a prompt execution of their orders by trading with the dealer, but their orders may not be executed at the equilibrium price. Dealers provide their services to anxious investors by bidding a price below the equilibrium and by asking a price above the equilibrium. An investor's dealer cost on a particular transaction is equal to the absolute difference between the unobservable equilibrium price and the actual transaction price. Consequently, in real securities markets, the transaction price changes in response to changes in the security's equilibrium value, plus it changes in response to the dealer cost.

The dealer cost can be operationally measured by either the spread, the percent spread, or the price change. By using these measures, earlier studies found that the amount of the dealer cost differs significantly among a given cross-section of transactions. The following section contains a discussion of the prior studies that have examined the factors which influence the size of the dealer cost at a given point in time.

PRIOR STUDIES ON THE DETERMINANTS OF DEALER COST

Recent studies have identified certain information factors which determine the expected dealer costs among a cross-section of transactions. These factors may be divided into three broad categories: (1) security factors; (2) market factors; and (3) transaction order factors.

Security Factors

One of the categories of information factors which affects the dealer cost is the following set of characteristics directly related to the security itself: the security's price, the security's expected rate of trading volume, and the security's risk.

The Security's Price

All researchers who have investigated the dealer costs support a positive relationship between the price of the security and the spread. Security price is one of the original spread determinants that Demsetz examined.[4] Every subsequent study has supported a very significant relationship which may be interpreted from two viewpoints. First, for determining the dealer's inventory costs, the relevant measure of the inventory is the dollar value of the holdings and not the number of shares. The dealer will insist on a higher spread per share for higher priced securities to offset the greater opportunity cost of the additional funds he commits. Second, assuming everything equal except price, traders will engage in arbitrage activities that will tend to equalize spread per dollar traded. Thus, the higher price security will experience a higher spread.

Although studies support a positive relationship between the price of a security and the spread, the association does not appear to be strictly linear. If the relationship were strictly linear, percent spread would be invariant with respect to security price. In fact, there are at least two reasons why percent spread will be negatively related to security price. First, dealers incur certain minimum fixed execution costs per 100 shares. For a given number of shares, the higher price stocks allow these fixed costs to be distributed over a greater dollar value traded. Eventually, as price increases, costs per dollar value traded will decrease. Second, in a fractional pricing

---

[4] Demsetz, "The Cost of Transacting," p. 45.

system rather than a decimal pricing system, lower priced stocks might incur an artificially high percent spread. For example, the minimum allowable spread on the American Stock Exchange is one-eighth, unless the price falls below one dollar.[5] Empirical tests have supported the non-proportionality of percent spread.[6]

The Security's Expected Rate of Trading Volume

The dealer's expected cost associated with a transaction depends, in part, on the security's expected rate of trading volume. The dealer prefers an active security, because it provides a greater opportunity to buy and sell the security. With higher trading volume the dealer incurs lower holding period costs on his security inventory.

A security's trading volume fluctuates daily in terms of its absolute and relative volume. However, cross-sectional spread studies have generally employed long-run measures of trading volume to match their calculations of long-term spread computed as the arithmetic average of actual spreads observed over the sample period. The two basic characteristics that affect a security's long-run rate of trading volume are its number of shareholders and its ownership characteristics.

Number of shareholders. In the long run, an important determinant of a security's expected trading volume is its number of shareholders. Both Demsetz and Hamilton found a significant, negative relationship

---

[5] Ben Branch and Walter Freed, "Bid-Asked Spreads on the Amex and the Big Board," Journal of Finance 32 (March 1977): 159-64.

[6] Non-proportionality of percent spreads with respect to price has been found on all major markets. See Branch and Freed, "Bid-Asked Spreads," p. 164; or George J. Benston and Robert L. Hagerman, "Determinants of Bid-Asked Spreads in the Over-the-Counter Market," Journal of Financial Economics 1 (December 1974): 353-64.

between spread and the natural logarithm of the number of shareholders.[7] Other studies measured long-run trading volume by averaging either share volume or dollar volume of trading over the sample period.[8] The results of these studies indicated a significant, negative relationship with the spread.

Ownership characteristics. There is a debate over the question of how institutional ownership of a security will affect its spread. Some market observers contend that an increase in the number of institutional owners will induce a larger spread for all transactions of any size because institutional transactions are usually much larger than individual transactions, and large trading imbalances would force the dealer to absorb huge amounts of inventory. Therefore, the dealer would widen his spread for all investors to compensate for this potential increase in holding costs.

In contrast, one may argue that an increase in the number of institutional owners may actually reduce spreads. Because institutions usually do not trade in parallel,[9] portions of a large institutional

---

[7] Demsetz, "The Cost of Transacting," p. 49; and James L. Hamilton, "Competition, Scale Economies, and the Transaction Costs in the Stock Market," Journal of Financial and Quantitative Analysis 11 (December 1976): p. 788.

[8] For a test of average daily volume see Seha Tinic, "The Economics of Liquidity Services," The Quarterly Journal of Economics 86 (February 1972): 79-93.

[9] Alan Kraus and Hans R. Stoll, "Parallel Trading by Institutional Investors," Journal of Financial and Quantitative Analysis 7 (December 1972): 2107-38.

trade can be matched through a network of institutional brokers, thus reducing any imbalance the dealer may choose to absorb. For the portion the dealer does absorb, he receives a larger price inducement so the price on normal size transactions should not be adversely affected. In fact, one may contend that the combination of numerous institutional owners and the well-developed institutional broker network provides the dealer a quicker and more flexible avenue for security inventory adjustment.[10] This combination reduces the dealer's holding costs so the individual investor would benefit on his trades in the form of lower spreads.

Four investigations that examined the impact of institutional ownership on security spreads reported a significant, negative relationship. Tinic found lower spreads on the New York Stock Exchange (NYSE) for securities that had a higher number of institutional owners.[11] Hamilton supported Tinic's findings for an alternative (NYSE) sample for an Over-the-Counter (OTC) market sample.[12] Barnea

---

[10] Empirical support for a negative relationship between institutional trading and stock volatility for the aggregate stock market is contained in: Frank K. Reilly, "Institutions on Trial: Not Guilty," Journal of Portfolio Management, Vol. 3, No. 2 (Winter, 1977), pp. 5-10; Frank K. Reilly and John M. Wachowicz, Jr., "How Institutional Trading Reduces Market Volatility," Journal of Portfolio Management, Vol. 5, No. 2 (Winter, 1979), pp. 11-17; Frank K. Reilly, "Block Trades and Stock Price Volatility," Financial Analysts Journal, forthcoming; and Neil Barkman, "Institutional Investors and the Stock Market," New England Economic Review, Federal Reserve Bank at Boston (November/December, 1977), pp. 60-78.

[11] Tinic, "The Economics of Liquidity Services," p. 90.

[12] James L. Hamilton, "Marketplace Organization and Marketability: NASDAQ, the Stock Exchange, and the National Market System," Journal of Finance 33 (May 1978): 496-97; and Hamilton, "Competition," p. 788.

measured institutional ownership as the security's percentage holdings by institutions and the results likewise indicated that institutional ownership reduces a security's spread.[13]

The Security's Risk

The theory and evidence concerning the affect that a security's risks has on its spread makes three assumptions. First, each dealer only provides quotations for one security. Second, because all traders possess the same information at any point in time, their estimated equilibrium prices are approximately the same. And, finally, dealers are always risk adverse.

The dealer incurs a loss when the equilibrium value moves in a detrimental direction depending on whether the dealer has a long or short position. He loses on a long position when the equilibrium price falls, and loses on a short position when the equilibrium price rises. Because stocks with a more volatile equilibrium value will be more costly to him, the dealer will widen spreads on volatile stocks to compensate for the greater risk.

Two operational measures of price volatility that have been tested are the price variance and the relative price range (the difference between the high price and the low price divided by the average price).

---

[13] Amir Barnea, "Performance Evaluation of New York Stock Exchange Specialists," Journal of Financial and Quantitative Analysis 9 (September 1974), p. 530.

Barnea and Stoll reported a significant, positive association between price variance and spread.[14] In contrast, Tinic did not find any relationship between the price variance and the spread.[15] Tinic's findings are questionable, since he used only nineteen consecutive daily closing prices to compute the security's variance. Tests of the association between the relative price range and the spread have also produced mixed results. Tinic and West observed a significant, positive relationship for a Toronto Stock Exchange sample, but found an insignificant relationship for both a NYSE sample and an OTC Market sample.[16] Hamilton, who used the natural log of the relative price range, found a significant, positive association with percent spread on both the NYSE and the OTC Market.[17]

The dealer's behavior toward security risk may be different if the dealer is allowed to handle more than one security and the security's risk is viewed within the context of his portfolio. Total security risk within a portfolio context can be decomposed into systematic risk and unsystematic risk. If the dealer holds a sufficient number of

---

[14] Barnea, "Performance Evaluation," p. 530; and Stoll, "Pricing Dealer Services," p. 1165.

[15] Tinic, "Economics of Liquidity Services," p. 90.

[16] Seha M. Tinic and Richard R. West, "Marketability of Common Stocks in Canada and the U.S.A.: A Comparison of Agent Versus Dealer Dominated Markets," Journal of Finance 24 (June 1974): 729-46.

[17] Hamilton, "Competition," p. 788; and Hamilton, "Marketplace Organization," pp. 496-97.

securities, much of the unsystematic risk for individual stocks should be eliminated. This would leave the systematic risk as a measure of the risk level that is relevant to the dealer.

Benston and Hagerman argue that the level of systematic risk would not affect spreads because the returns from holding the security compensate the dealer for his opportunity cost of risk.[18] They found an insignificant relationship between spread and systematic risk for a sample of OTC securities which supports their hypothesis.

On the other hand, Stoll claims that a security's systematic risk is relevant to the dealer's cost because when the dealer facilitates trading imbalances, he moves along the efficient frontier to a less desirable point.[19] Thus, the returns from holding the security do _not_ fully compensate him for his lower utility. Stoll found a significant, positive relationship between systematic risk and spread for an OTC sample.

Insider trading also impacts the dealer's behavior toward risk. Assuming the dealer has the same information as other investors, is not realistic. The fact is, there is inside trading by investors who have information concerning the equilibrium price that is superior to the dealer's information. Because the dealer cannot identify insiders' transactions he will always lose on these transactions. The dealer must widen his spread on every transaction to compensate for the extra costs of insider trading. If the level of insider trading differs

---

[18] Benston and Hagerman, "Determinants," pp. 353-64.

[19] Stoll, "Pricing Dealer Services," pp. 1153-72.

among securities, then a measure of insider trading should be positively related to the spread.

Since insider trading is not directly observable, three alternative measures have been proposed and tested. Benston and Hagerman hypothesized that insider trading must be measured by unsystematic risk.[20] Since unsystematic risk measures the firm specific risk with market movements accounted for, a stock with higher unsystematic risk provides a greater opportunity to profit on inside information. Benston and Hagerman felt the results supported their hypothesis, because they found a significant, positive relationship between spread and unsystematic risk. However, their findings may also be interpreted as an indication of insufficient portfolio diversification. Stoll assumes that a measure of a security's insider trading is its turnover (dollar value traded divided by dollar value of shares outstanding because for a given amount of shares outstanding, higher trading means that there is more informational trading.[21] Stoll's measure was significant and positive in relation to the spread. Yet, one may contend that trading turnover is a function of a number of other factors such as investors' varying liquidity needs and institutional portfolio rebalancing. Therefore, trading turnover is a poor proxy for the level of insider trading. Finally, Barnea and Logue measured insider trading by the risk rating of <u>Financial World</u> because a higher risk security offers a better opportunity for profitable insider trading.[22]

---

[20] Benston and Hagerman, "Determinants," pp. 353-64.

[21] Stoll, "Pricing Dealer Services," p. 1163.

[22] Amir Barnea and Dennis E. Logue, "The Effect of Risk on the Market Maker's Spread," <u>Financial Analysts Journal</u> 31 (November-December 1975): 45-49.

The ratings were significantly related to spreads. All three operational measures of a security's insider trading level were found to be positively related to the spread.

Market Factors

Dealer cost is also affected by the characteristics of the market in which the transaction occurs. A *market factor* is defined as a *structural aspect of the dealer organization* which influences the dealer's operating expense or *the nature of competition among the dealers*.

Designated Marketplace Structure

The *designated marketplace* is a specific association of members who assemble bids and offers. Examples of designated marketplaces are the New York Stock Exchange (NYSE), the American Stock Exchange (ASE), the Over-The-Counter market (OTC), and the Toronto Stock Exchange (TSE). The way the dealers are organized differs among the alternative marketplaces. On the NYSE and the ASE, there is typically only one dealer assigned to each security and their activity is monitored by the exchange. In contrast, OTC dealers are free to act independently. The structure of the TSE favors an agency type market which discourages exchange members from providing dealer services outside of odd-lot trading. These structural differences may affect the dealer cost of a transaction while holding other factors constant.

Two studies examined the influence of the marketplace on dealer costs. Tinic and West discovered significant differences among three alternative marketplaces.[23] The rank of dealer cost for lowest to highest was the NYSE, OTC, and TSE. Hamilton also found the NYSE offered cheaper dealer services relative to the OTC; however, he questioned Tinic and West's sampling procedure.[24] Tinic and West's marketplace samples were unmatched in time, because they compared a March 1969 OTC sample to a November 1971 NYSE sample. If dealer costs vary over time, the difference of thirty-one months between their samples could affect their findings. Hamilton matched his samples in time, controlled for more dealer cost influences and found the NYSE spread was 4 percent lower than the OTC spread.

Designated Security Structure

The designated security structure is the degree of dealer concentration for a particular security--i.e., the number and size distribution of the dealers from all of the marketplaces. Dealer concentration affects the intensity and the effectiveness of dealer competition--e.g., numerous competing dealers who are relatively equal in size reduce the spread.

As noted previously, for a cross-section of securities, there is a negative relationship between the rate of trading volume and the spread. It is important to determine whether this relationship is true for the individual dealer firm or for the industry of dealer firms who provide quotations on a specific security. On the one hand, competition would be ineffective if the individual dealer firm faces a

---

[23] Tinic and West, "Marketability: A Comparison," p. 741.

[24] Hamilton, "Marketplace Organization," p. 489.

decreasing marginal cost curve, because the optimal size for the individual dealer firm would grow so large in relation to the market that there would be only room for one dealer firm. Alternatively, competition is effective if the economies of scale only apply to the industry and not to the individual firm. In the latter case, the industry's marginal cost curve would decrease as output increases; yet, the firm's marginal cost curve would be "U shaped" over the relevant volume levels.[25] Under these conditions, economies of scale are internal to the industry, but external to the firm. Higher output levels for the industry would benefit the firm by shifting the firm's cost curve down. The empirical tests of these two opposing views indicate that economies of scale apply only to the industry which means that competition is an effective force. Specifically, higher volume levels were positively related to the number of dealers in contrast to the natural monopoly case that would predict no association between the two variables.[26]

A number of studies found that dealer concentration in a security affects its spread. All of the investigations of OTC competition support a significant, negative relationship between the number of dealers for a security and its spread.[27] In addition, Stoll predicted that

---

[25] Stoll, "Pricing Dealer Services," pp. 1153-72.

[26] Seha M. Tinic and Richard B. West, "Competition and the Pricing of Dealer Service in the Over-The-Counter Stock Market," *Journal of Financial and Quantitative Analysis* 7 (June 1972): 1707-27; Stoll, "Pricing Dealer Services," p. 1165.

[27] Tinic and West, "Competition," pp. 1707-27; Benston and Hagerman, "Determinants," pp. 360-61; Hamilton, "Marketplace Organization," pp. 496-97; and Stoll, "Pricing Dealer Services," p. 1165.

the relative size of the dealers influences the level of competition.[28] He found a positive association between spread and the amount of volume centralized among dealers. Together, the studies show that both the number and size distribution of dealers affects spreads.

Although there is typically only one dealer (i.e., specialist) named per stock on the NYSE, it is possible to show that dealer concentration affects the spread. In this case competition comes from outside markets where the security is traded (i.e., regional stock exchanges and the OTC market). External competition is measured by counting the number of competing markets where the stock is traded. Using this approach, Demsetz found no relationship to spreads, while studies by Hamilton and Branch and Freed supported the hypothesized negative relationship between external competition and spread.[29] Tinic considered both the number of outside markets and their volume characteristics by computing the Herfindal Index of Concentration which considers both the number of markets and the distribution of trading activity among markets. Using this Index, Tinic found a negative relationship between NYSE spreads and external competition.[30]

Transaction Order Factors

Transaction order factors are characteristics directly related to the nature of the trade including size of the trade and the active

---

[28] Stoll, "Pricing Dealer Services," p. 1164.

[29] Demsetz, "Cost of Transacting," p. 49; Hamilton, "Marketplace Organization," pp. 496-97; and Branch and Freed, "Bid-Asked Spreads," p. 161.

[30] Tinic, "The Economics of Liquidity Services," p. 90.

side of the trade (whether the trade is initiated by an anxious seller or by an anxious buyer).

Share Size of the Transaction Order

The share size of a transaction should be positively related to the dealer cost because of the greater expenses involved in relatively larger transactions. Large-scale share orders increase the probability that the order will not be matched as quickly because the dealer may have difficulty locating the other size of the trade. Thus he incurs higher inventory holding costs and greater search costs for locating matching orders. Therefore the dealer quotes his bid and offers prices further away from the equilibrium price for large transactions.

Those who believe that transaction share size affects dealer costs would expect a relatively large dealer cost on block trades. Hence, several studies analyzed the intra-day price behavior linked to the block transaction. Two common measures of block price behavior are the price impact and the price reversal. The *price impact* is typically defined as the percentage price change computed from the price on a trade made *before* the block transaction, to the price on the block transaction. The *price reversal* is defined as the percentage price change computed from the price on either the block transaction or on a trade executed during the immediate post block period, to the day's closing price.

The behavior of the price impacts and the price reversals can be used to test whether dealer costs are affected by block trades. On the one hand, a large dealer cost on blocks would cause a major price impact, since price changes are a function of both the dealer cost and the change in the equilibrium price. The relatively larger dealer cost is primarily related to the block transaction, so its effects are only temporary. *Therefore, if block trades have greater dealer costs, the price reversal should be substantial in size and in the opposite direction of the price impact*. On the other hand, a negligible dealer cost on blocks would imply that the price impact is essentially caused by an equilibrium value change. *Consequently, if block trades have no affect on dealer costs, the price reversal would be relatively insignificant*.

Kraus and Stoll conducted the first major analysis of the price impacts and price reversals on block trades.[31] They examined 7,009 NYSE block transactions divided into positive tick blocks, zero tick blocks, and negative tick blocks.[32] The tick classifications identify the active and passive sides of a trade. The tick tends to be positive when there is an anxious buyer and generally negative when there is an anxious block seller.[33] Kraus and Stoll found that the average price impact, calculated from the price immediately prior to the block transaction, was -1.14 percent for minus tick blocks followed by a significant average price reversal for the minus tick blocks equal to .71 percent. This evidence supports the hypothesis that dealer costs *are* affected by the size of transactions, because of the size and direction of the price reversal. The rapid price recovery on minus

---

[31] Alan Kraus and Hans R. Stoll, "Price Impacts of Block Trading on the New York Stock Exchange," *Journal of Finance* 27 (June 1972): 88.

[32] The sign of the tick refers to the relationship of the price on the block transaction relative to the price on the trade prior to the block transaction.

[33] Kraus and Stoll, "Price Impacts," p. 573.

tick blocks is consistent with the temporarily large dealer cost necessary to exchange a large number of shares quickly.

A study by Trippi and Nora examined NYSE blocks during an alternative time span (March 1973 through August 1973) and derived results similar to Kraus and Stoll.[34] Another study by Close found significant dealer cost price effects for trades of $100,000 or more on the Montreal and Toronto Stock Exchanges.[35]

Grier and Albin examined the price reversal on blocks from the viewpoint of market efficiency.[36] They calculated the price impacts from the opening price for a sample of blocks. A filter rule ranked the price impacts in deciles from the lowest to the highest. Price reversals computed using the block transaction price indicated an average price reversal of <u>2.12 percent</u> for blocks with the lowest price impact. The size of the price reversal clearly indicated that block dealer costs are substantially higher than on normal size trades. However, caution must be used if one interprets the results as evidence contrary to the efficient market hypothesis.[37]

---

[34] Robert R. Trippi and Yuris Nora, "An Analysis of Price Impacts of Large Block Transactions on the New York Stock Exchange," <u>Journal of Economics and Business</u> 28 (Winter 1976): 88-95.

[35] Nicholas Close, "Price Reaction to Large Transactions in the Canadian Equity Markets," <u>Financial Analysts Journal</u> 31 (November-December 1975): 50-57.

[36] Paul C. Grier and Peter S. Albin, "Nonrandom Price Changes in Association with Trading Large Blocks," <u>Journal of Business</u> 46 (July 1973): 425-33.

[37] <u>All</u> costs of operating trading rules must be considered before interpreting the price reversal results as evidence of market inefficiency. See Robert Reback, "Nonrandom Price Changes in Association with Trading in Large Blocks: A Comment," <u>Journal of Business</u> 47 (October 1974): 564-65.

A study by Carey created deciles of block price impacts similar to Grier and Albin and calculated three price reversals for each decile, based upon the prices on the following trades: the block transaction, the first trade occurring one minute after the block transaction, and the first trade occurring fifteen minutes after the block transaction.[38] The computed price reversals in the decile with the lowest price impacts were the following: 2.95 percent for a purchase on the block transaction; 1.90 percent assuming a trade made one minute later; and .59 percent assuming the trade occurred after fifteen minutes had elapsed. This implies that dealers for anxious block sellers receive a 2.95 percent gross return. Notably, the abnormally large block dealer cost is very temporary since the observable price impacts change considerably in just one minute after the block transaction.

A study by Dann, Mayers, and Raab calculated the following five types of price reversals: purchase at the block, plus trades at one, five, ten, and fifteen minutes after the block.[39] Their results suggest that "trading rule profits, net of commissions and transfer taxes, ...evaporate within one minute after the block."[40] The analysis implies that excess dealer costs occur primarily on the block transaction and that the abnormal dealer cost declines significantly on trades made during the immediate post block period. In fact, prices on trades made just fifteen minutes after the block transaction are

---

[38] Kenneth J. Carey, "Nonrandom Price Changes in Association with Trading in Large Blocks: Evidence of Market Efficiency in Behavior of Investor Returns," Journal of Business 50 (October 1977): 407-414.

[39] Larry Y. Dann, David Mayers, and Robert I. Raab, "Trading Rules, Large Blocks and the Speed of Price Adjustment," Journal of Financial Economics 4 (January 1977): 3-22.

[40] Ibid., p. 18.

unbiased estimators of the closing prices which means the abnormal dealer cost evaporates entirely within fifteen minutes.

An implication of the relationship between transaction share size and dealer costs is that the absolute size of the price impact should be positively correlated with the size of the block because the dealer requires additional compensation with the larger transactions. The results of the two studies confirm this relationship. Kraus and Stoll found a statistically significant positive relationship between the absolute value of the price impact and the dollar value of both plus and minus tick blocks.[41] A study by Radcliffe likewise revealed a statistically significant positive relationship between the absolute value of the price impact and the share size of the blocks.[42]

In contrast, Scholes argued that the size of transactions has no effect on dealer costs.[43] Scholes analyzed the abnormal dealer cost associated with secondary distributions rather than block trades.[44] When Scholes examined price reversals in a manner similar to the Kraus and Stoll study the results were as follows: a) the price reversal was insignificant in size, and b) the correlation between the size of

---

[41] Kraus and Stoll, "Price Impacts," p. 582.

[42] Robert C. Radcliffe, "Liquidity Costs and Block Trading," Financial Analysts Journal 29 (July-August 1973): 73-80.

[43] Myron S. Scholes, "The Market for Securities: Substitution Versus Price Pressure and the Effects of Information on Share Prices," Journal of Business 45 (April 1972): 179-211.

[44] A secondary distribution is a method of selling a large number of securities. A syndicate of brokers is generally found and the sale is made after the market is closed.

the secondary distribution and the absolute price impact was statistically insignificant. Therefore, Scholes argues that large transactions do not influence dealer costs. Kraus and Stoll disagreed with Scholes' interpretation of the statistical results because they contended that secondary distributions differed from block trades for the following reasons: a) the seller pays commission fees on both the buy and sell side and b) secondary distributions generally take more than a day to complete.[45] Since the seller pays a double commission the additional costs of handling a large transaction are taken care of by an abnormal commission fee rather than an abnormal dealer cost.

Active Side of the Trade

The dealer cost may be influenced by whether a transaction is initiated by an anxious seller or by an anxious buyer. The Demsetz assumption that the equilibrium price is equal to the mid-point of the bid-ask spread implies that dealer costs on normal size trades are equal for anxious sellers and buyers.[46] However, the results of the Kraus and Stoll study suggest that dealer costs are not symmetric for block trades.[47] They divided their sample of block trades according to the signs of the blocks' ticks and found that the price impacts and price reversals were significantly different for minus versus plus tick blocks. The average price impact on plus tick blocks (.71 percent) was smaller than on minus tick blocks (1.14 percent). Of

---

[45] Kraus and Stoll, "Price Impacts," pp. 586-87.

[46] Demsetz, "The Cost of Transacting," p. 37.

[47] Kraus and Stoll, "Price Impacts," pp. 573-74.

more importance, the average price reversal on plus tick blocks was only .09 percent compared to .71 percent on minus tick blocks. Kraus and Stoll explained this difference as a function of the block dealers' alternative operating methods. While block dealers acquire security positions to facilitate the needs of anxious block sellers, block dealers rarely take a short position to facilitate a block purchase. Therefore, the dealers' inventory costs are primarily associated with minus tick blocks. However, one should be cautious with Kraus and Stoll's interpretation since they did not control for any differences in the average share size between plus and minus tick blocks.

Summary

An imperfect transaction market is characterized by temporary excess demand and supply at the equilibrium price. The security dealer provides anxious investors the assurance of an immediate offsetting order by maintaining continuous price quotations for a quick sale or purchase of securities. Since the dealer quotes his bid and offer away from the perceived equilibrium price, anxious investors incur a dealer cost on their transactions. Therefore, price volatility in an imperfect transaction market is caused by both changes in the equilibrium price and the dealer cost.

There are three proxies of the dealer cost: the bid-ask spread, the percent bid-ask spread, and the transaction-to-transaction price change. Prior studies have identified three major categories of information factors which can explain cross-sectional dealer cost differences: security factors, market factors, and transaction factors.

The analyses of the security factors has indicated that the bid-ask spread is positively correlated with the price per share although the relationship is not strictly linear. Further, the expected rate of trading volume is negatively related to the bid-ask spread because the level of volume basically determines the length of the holding period. In turn, trading volume is a function of both the number of shareholders and the amount of institutional ownership. Finally, it was shown that dealers widen their spreads on riskier stocks although there is a controversy on the relevant risk measure (i.e., the security's systematic risk, unsystematic risk, or total risk).

Dealer costs are also determined by the characteristics of the market in which the transaction occurs. The study results indicate that alternative security exchanges have significantly different bid-ask spreads and bid-ask spreads are inversely associated with dealer competition.

An analysis of the impacts of the transaction order indicated that the size of a transaction is positively related to the dealer cost although the abnormally large dealer costs quickly evaporate after the block trade. Also the evidence indicates that anxious block sellers pay a higher dealer cost than anxious block buyers.

SECURITY DEALER COSTS IN THE BLOCK TRANSACTION MARKET

One of the acknowledged features of a transaction that affects dealer costs is the number of shares traded. For a large trade, it is less likely that a matching order of the same size will exist simultaneously. Thus it will require greater dealer participation in the trade. Therefore, data on large security transactions is especially useful for a time series analysis of dealer behavior. This section focuses on growth of the block market, the block dealer market, and the block price reaction (BPR) indices that are used in the analysis.

Institutional Activity and Block Trades

As shown in Table 1 block trading activity has grown dramatically since 1965. This growth in block trading activity is the results of two factors. First, total trading activity by large institutional investors has increased over time. Second, there has also been a substantial increase in the proportion of total institutional trading done in blocks.

The figures in Table 1 indicate that the dollar value of common stock purchases and sales by major financial institutions has tripled since 1965. In addition, the proportion of institutional purchases and sales to the total dollar volume on all exchanges has increased from .259 in 1965, to .377 in 1977. Currently, there is an average of almost 300 block trades a day and about one of every five shares bought and sold on the NYSE is through a block transaction. While the table stops in 1977 it is known that the block market experienced further growth in 1978 and 1979 and there are no signs of a decline.

Supply of Block Dealer Services

Because the regular auction market could not adequately handle the increasing number of abnormally large transactions several of the large brokerage firms introduced a dealer service specifically designed to facilitate block transactions.[48] As a result, the large brokerage firms are now the primary source of block dealer services.

---

[48] For a further discussion on this topic see Frank K. Reilly, Investment Analysis and Portfolio Management (Hinsdale, Ill.: The Dryden Press, 1979), Chapter 4.

TABLE 1

TOTAL INSTITUTIONAL TRANSACTIONS, TOTAL TRANSACTIONS ON ALL EXCHANGES
AND BLOCK TRADING VOLUME: ANNUAL DATA 1965-1977

ear	Value of Total Stk. Purch. and Sales By Institutions[a] ($ Millions)	Value of Stock Volume on All Exchanges[a] ($ Million)	Total Inst. Trades as Percent of Total Exch. Vol. (Percent)	Number of Block Transactions[b]	Number of Block Shares[b] (Million shs.)	Dollar Value of Block Trans.[b] ($ Million)	Block Vol. as Percent of NYSE Vol.[b] (Percent)	Block Vol. as Percent of Inst. Vol (Percent)
965	23,160	89,255	25.9	2,171	48.2	1,857.4	3.1	8.0
966	33,120	123,034	26.9	3,642	85.3	3,303.2	4.5	10.0
967	48,645	161,746	30.1	6,685	169.4	6,811.1	6.7	14.0
968	67,245	196,358	34.2	11,254	292.7	12,971.5	10.0	19.3
969	79,960	175,297	45.6	15,132	402.1	15,609.4	14.1	19.5
970	68,435	131,126	52.2	17,217	450.9	13,354.0	15.4	19.5
971	92,340	185,031	49.9	26,941	692.5	24,204.4	17.8	26.2
972	101,575	204,026	49.8	31,207	766.4	26,284.1	18.5	25.9
973	85,910	177,872	48.3	29,233	721.4	20,975.9	17.8	24.4
974	51,525	118,242	43.6	23,200	549.4	11,879.1	15.6	23.1
975	66,438	157,025	42.3	34,420	778.5	19,407.9	16.6	29.2
976	73,694	194,963	37.8	47,632	1,001.3	29,216.3	18.7	39.6
977	70,650	187,202	37.7	54,275	1,183.9	33,990.7	22.4	48.1

Source: Statistical Bulletin, United States Securities and Exchange Commission, Vols. 16-28 (1966-1978).

Source: Large Blocks, Research and Planning Department, New York Stock Exchange, 1978.

A block dealer may be defined as any person or firm who is continuously in contact with market participants and who is willing to provide bid and offer price quotations on block size transactions.[49] The block dealers differ from other dealers in the following ways: block dealers are large brokerage firms; block trades are negotiated over the dealers' communication network rather than auctioned on the exchange floor; block market participants are financial institutions rather than individual investors.

Number of Blocks According to the Tick Sign

NYSE blocks may be divided into three categories on the basis of whether their tick sign was positive, zero, or negative. The tick sign can identify the anxious party of a block trade, i.e., whether the block was executed by an anxious block purchaser (a positive tick) or an anxious seller (a negative tick). Table 2 contains the percent of blocks according to tick. The table supports the notion that blocks are sold not bought--i.e., there is a propensity to sell a position through a block transaction, but positions are typically accumulated through smaller purchases over a period of time. Specifically, 40.1 percent of the blocks had negative ticks while only 18.7 percent of the blocks had positive ticks. The high proportion of zero

---

[49] A recent survey of institutions ranked the brokerage firms who were the "best for block handling." The top four firms out of the list of twenty were Goldman Sachs and Co.; Salomon Brothers; Morgan Stanley and Co. Inc.; and Merrill Lynch, Pierce, Fenner, and Smith, Inc. Peter Z. Grossman, "Who are Wall Street's Best Brokers?" Financial World, 1 December 1978, p. 21.

TABLE 2

DAILY OBSERVATIONS OF NYSE BLOCK TRADES-- NUMBER OF POSITIVE TICK, ZERO TICK AND NEGATIVE TICK BLOCKS AS A PERCENT OF THE TOTAL NUMBER OF BLOCKS 1972-1977

Year	Positive Tick Blocks		Zero Tick Blocks		Negative Tick Blocks	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1972[a]	14.5	9.6	56.2	25.8	29.3	18.0
1973	14.7	4.8	40.0	5.9	45.4	7.8
1974	13.6	5.2	38.7	6.5	47.7	7.7
1975	19.8	5.4	39.1	5.9	41.1	7.8
1976	23.1	5.4	43.2	6.1	33.6	7.2
1977	22.1	5.1	44.5	7.8	33.5	7.7
Total Period	18.7	6.3	41.2	6.7	40.1	9.3

tick blocks, 41.2 percent, is reflective of the specialist's limit orders that must be executed prior to the block transaction.

The Block Price Reaction Indices

As noted, this study analyzes the time series properties associated with the intertemporal variation of dealer costs by examining the transaction-to-transaction price behavior of large security transactions. More specifically, the study will examine the *block price reaction indices* (BPR) which have the following characteristics:

A) *Transactions of 10,000 shares or more*. The New York Stock Exchange (NYSE) defines a *block trade* as a transaction of 10,000 shares or more. Block trades make up a subset of all transactions such that the elements of this subset possess a mutual minimum transaction share size criteria.

B) *New York Stock Exchange Transactions*. Transactions executed in alternative marketplaces may cause differences in dealer costs.[50] Since this analysis centers on transactions executed on the NYSE, the effects of marketplace differences is eliminated.

C) *Transactions-to-transaction percentage price changes*. A percentage price change is computed for each individual NYSE block transaction. The percentage price change is computed *from* the price of the transaction immediately prior to the block trade *to* the price on the block trade itself. The transaction-to-transaction price change is the most direct indication of the dealer cost linked to

---

[50] Seha [50] Seha M. Tinic and Richard B. West, "Marketability of Common Stocks in Canada and the U.S.A.: A Comparison of Agent Versus Dealer Dominated Markets," *Journal of Finance* 24 (June 1974): 726-746.

a particular block transaction. The individual NYSE block price changes are subdivided into three categories according to whether the price changes are positive, zero, or negative.

D) Daily Arithmetic average. The basic unit of time in this study is the daily trading session. For each day, two arithmetic averages are computed from the individual NYSE block price changes. One average is computed for all positive price changes and another average is computed for all negative price changes. If expected dealer costs change systematically over time, temporal dealer cost factors can affect the whole set of block trades, but the magnitude of impact need not be the same for all blocks. Consequently, these price changes must be averaged over many block trades in order to sort out the systematic influences from factors that are unique to particular blocks.

The daily average (either negative or positive) of transaction-to-transaction percentage price changes associated with NYSE blocks will be referred to as the block price reaction. More formally, the two block price reaction indices are defined as:

$$BPR_n(t) = \frac{1}{V(t)} \underset{i=1}{\overset{V(t)}{}} \frac{B_i(t) - P_i(t)}{P_i(t)}$$

and

$$BPR_p(t) = \frac{1}{W(t)} \underset{j=1}{\overset{W(t)}{}} \frac{B_j(t) - P_j(t)}{P_j(t)}$$

where,

$BPR_n(t)$ = Block Price Reaction for negative tick blocks on trade day t.

$BPR_p(t)$ = Block Price Reaction for positive tick blocks on trade day t.

$P_i(t)$ = Price per share of the last transaction *before* the *ith* negative tick block.

$P_j(t)$ = Price per share of the last transaction *before* the *jth* positive tick block.

$B_i(t)$ = Price per share of the *ith* negative tick block transaction on trade day t.

$B_j(t)$ = Price per share of the *jth* positive tick block transaction on trade day t.

$V(t)$ = Total number of negative tick blocks on trade day t. A negative tick block is a block transaction where the block price per share is *less* than the price per share on the preceding transaction. $(B_i(t) < P_i(t))$.

$W(t)$ = Total number of positive tick blocks on trade day t. A positive tick block is a block transaction where the block price per share is *greater* than the price per share on the preceding transaction. $(B_i(t) > P_i(t))$.

t = The particular trade day within the six year period of daily observations, t=1, 2, . . ., 1514.

The block price reactions for both negative and positive tick blocks are computed for *each* trading day. The time series consist of all days the NYSE was open over the time span of 1972 through 1977 (i.e., 1,514 daily observations). Plots of the block price reactions for both negative and positive tick blocks are illustrated in Figures One and Two respectively.

The Hypotheses

The analysis of the block price reaction time series tests the hypothesis whether expected dealer costs on block trades change over time. The null hypothesis states that each BPR index time series is a sequence of constant mean, uncorrelated random variables, i.e., the expected dealer cost on blocks is invariant over time. The alternative hypothesis states that successive observations of the BPR index are correlated and that the analysis of dealer costs must take into account the time order of the observations.

The alternative hypothesis argues that the behavior of each BPR index is the result of a mixture of causes. On the one hand, equilibrium price changes produce an irregular, random effect in the series. On the other hand, systematic intertemporal dealer cost variation brings about a degree of regularity in the series. The mixture of these causes, operating in parallel over time, create an orderly, nonrandom component in the block price reaction series. Therefore, the behavior of each BPR index bears a systematic element which can be isolated, identified, and described by an appropriate time series model.

If the statistical evidence refutes the null hypothesis, it is necessary to determine which temporal information factors can explain the behavior of the BPR indices. Based upon a consideration of the dealer cost literature, the causal relationship between block dealer costs and certain market variables is tested.

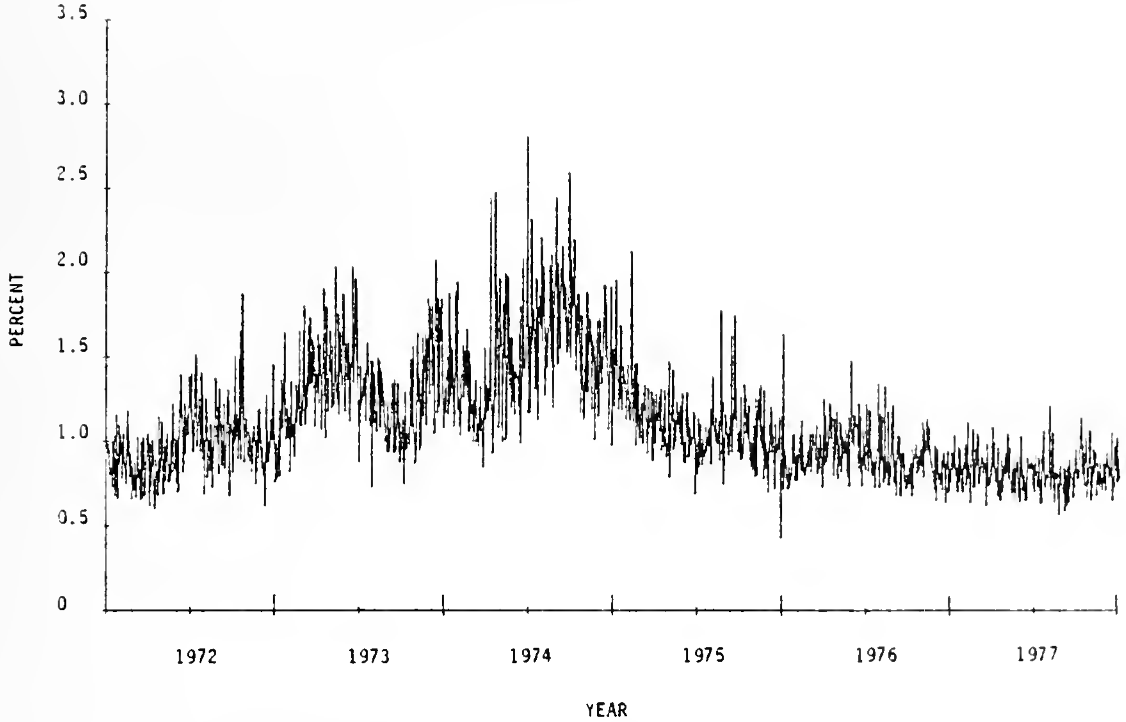

Fig. 1. Daily block price reaction index of negative tick blocks (BPR_n)

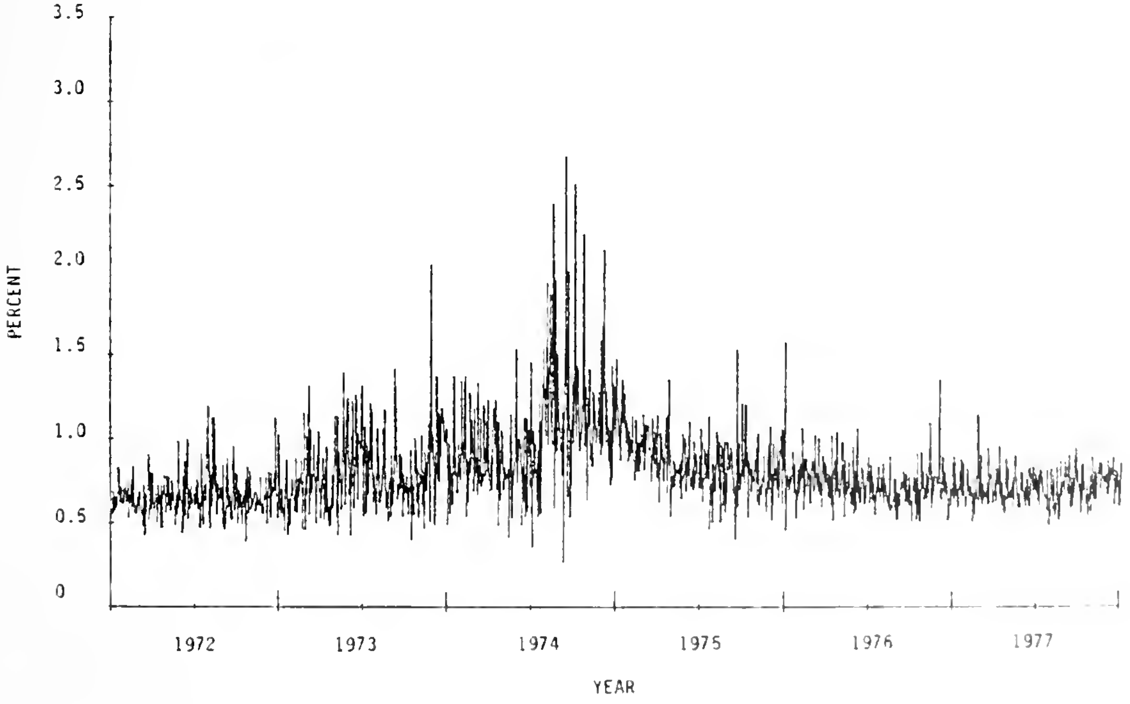

Fig. 2. Daily block price reaction index of positive tick blocks (BPR_p)

TIME SERIES ANALYSIS OF THE BLOCK PRICE REACTION INDICES

The primary goal of this section is to gain insights into block dealer cost behavior by constructing time series models of the BPR indices. Suitable models for the BPR indices may be found by following two basic steps. First, statistical tests determine whether the observations could have occurred in any order. Second, if the tests indicate that a simple white noise model does not sufficiently describe the BPR indices, then performance of additional tests can suggest more complicated models in both the time and frequency domain.

Descriptive Statistics of the BPR Indices

Plots of the BPR Indices are contained in Figures 1 and 2. Table 3 contains descriptive statistics for the daily observations of the BPR Indices. The plots and the table help determine whether the indices' variation may be explained by trend movements. Trend is the broad long-term movement in a time series whereby the mean of the process changes in a smooth manner extending over a considerable time period.[51] In this study, any deterministic monthly movement may be regarded as trend.

The results in Table 3 suggest that both indices behave in a similar manner, because they both exhibit their highest levels in 1974. In contrast, they are dissimilar in that the BPR_n index is usually greater than the BPR_p index and the apparent trend movement in the BPR_n index is more accentuated than the BPR_p index.

---

[51] The difficulty with this definition is what is meant by "long term." The idea of long term is a relative one, therefore, a practical definition of trend should take into account the unit of time and the number of available observations.

TABLE 3

DAILY OBSERVATIONS OF NYSE BLOCK TRADES--BLOCK PRICE REACTION INDICES

(Annual Descriptive Statistics for 1972-77)

	Positive Tick Blocks (BPR_p)				Negative Tick Blocks (BPR_n)			
Year	Mean	Std. Deviation	Minimum	Maximum	Mean	Std. Deviation	Minimum	Maximum
1972	0.660	0.124	0.39	1.19	0.977	0.196	0.60	1.87
1973	.791	.223	.40	2.03	1.298	.271	.73	2.07
1974	1.013	.342	.27	2.67	1.511	.338	.85	2.80
1975	.864	.178	.41	1.57	1.101	.208	.43	2.12
1976	.730	.117	.46	1.35	.915	.136	.64	1.47
1977	0.715	0.096	0.49	1.14	0.822	0.109	0.57	1.21
Entire 1972-77 Time Period	0.796	0.230	0.27	2.67	1.105	0.325	0.43	2.80

Tests of Weak White Noise Behavior

In this subsection we present the results of tests to determine whether the observations of either the BPR_n or the BPR_p time series were generated by a weak white noise process. A weak white noise process is defined as a sequence of uncorrelated, constant mean random variables. Both a runs test and an examination of the correlogram are applied to the BPR indices.

Runs Test. After each observation was assigned a plus or minus sign, the number of runs was tabulated and compared to the expected number under the assumption that the sample is random.[52] If the sample is random, the number of runs (R) is asymptotically normal with

$$E(R) = \frac{1}{3}(2T - 1)$$

and

$$V(R) = \frac{1}{90}(16T - 19)$$

where

R = number of runs;

$E(R)$ = expected number of runs if the sample is random;

$V(R)$ = variance of the number of runs;

T = total sample size.

Table 3 and the BPR time plots suggest a shifting population mean over time. Therefore, a left-tail test is appropriate, because the

---

[52] When successive observations were tied with each other, the zero change was disregarded so that the number of runs and sample size were reduced. See Ya-lun Chou, Statistical Analysis with Business and Economic Applications (New York: Holt, Rinehart and Winston, 1963, pp. 440-42.

presence of trend may create a situation where there are too few runs. The null hypothesis may be stated as "the sample is a random sample." That is, H_0: $R = E(R)$.

The alternative hypothesis may be stated as "the sample is non-random with a shifting population mean." That is, H_1: $R < E(R)$.

The results for the BPR_n index are the following. Under the null hypothesis,

$$E(R) = (\frac{1}{3})\ ((2)\ (1,481-1)) = 987$$

and

$$V(R) = (\frac{1}{90})\ ((16)\ (1,481-29)) = 262.97;$$

therefore, reject H_0 at the five percent significance level if:

$$R < 987 - 1.645\sqrt{262.97} = 960.32.$$

Since R = 959 for the BPR_n index, the null hypothesis is rejected.

For the BPR_p index, the null hypothesis implies that

$$E(R) = (\frac{1}{3})\ ((2)\ (1,475-1)) = 983$$

and

$$V(R) = (\frac{1}{90})\ ((16)\ (1,475-29)) = 261.9;$$

therefore, reject H_0 at the five percent significance level if:

$$R < 983 - 1.645\sqrt{261.9} = 956.3.$$

Since R = 984 for BPR_p index, the null hypothesis is accepted.

The runs test suggests that the BPR_n index is not random, but the BPR_p is random. However, caution must be used in the interpretation of the runs test results for BPR_p. It is conceivable that a process is not white noise, yet it might still be accepted as "random" by the runs test. For example, BPR_p observations may be characterized by a systematic swing above and below a changing trend. Thus, the systematic swing would increase the number of runs causing the randomness assumption to be accepted.

Correlogram. An examination of time series' autocorrelation coefficients may indicate the presence of trend. If a time series contains trend, then the autocorrelation coefficients will not come down to zero, except for very large lags. That is, an observation on one side of the overall mean tends to be followed by a large number of subsequent observations on the same side of the overall mean due to the changes in trend.

A linear trend was removed from each BPR index before calculating their autocorrelations. Specifically, the least squares method was used to estimate the coefficients in the following linear trend model:

$$BPR(t) = b_o + b_1 (t - \overline{t}) + e(t)$$

where,

$BPR(t)$ = observation of the block price reaction at time t;

$e(t)$ = residuals of the linear trend regression at time t;

b_o = mean of the time series;

b_1 = slope of the time series;

$$\overline{t} = \frac{\sum_{1}^{T} t}{T};$$

T = total number of observations.

Using this model, BPR_p had a mean and slope equal to .796 and .0000002, respectively. BPR_n had a mean and slope equal to 1.105 and -.0002528, respectively. Autocorrelation coefficients were calculated for the residuals to determine whether a higher order trend was still present in each series.

A useful aid in interpreting a set of autocorrelation coefficients is a graph called a correlogram in which the coefficients are plotted against the lag. Correlograms of the BPR_p and BPR_n trend residuals are given in Figures 3 and 4, respectively. The autocorrelation coefficients are shown for lag zero through lag 400. Notably, both correlograms clearly indicate the presence of a non-linear trend, because the autocorrelation coefficients do not come down to zero until the lag at approximately 300.

In sum, both the runs test and the correlogram suggest that BPR_n is not weak white noise, because the series clearly exhibits a strong non-linear trend. In contrast, there are conflicting results for the BPR_p index since the runs test suggests that the BPR_p index is random, but the correlogram indicates a relatively weak trend.

Identification of Trends in the BPR Indices

The previous section indicates that both indices are more complicated than simple weak white noise. When describing the non-random behavior of the BPR indices, it is convenient to represent each index as the sum of a trend component and a residual (irregular) component.[53] More specifically,

---

[53] No obvious cycles or seasonal movement is apparent in the BPR time plots, therefore, a cyclical component has been left out of the model.

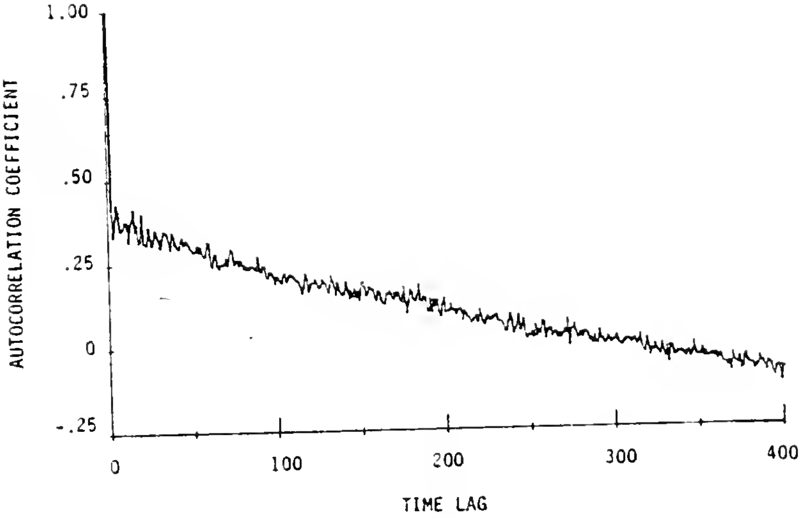

Fig. 3 Correlogram for the positive tick block price reaction index BPR_p

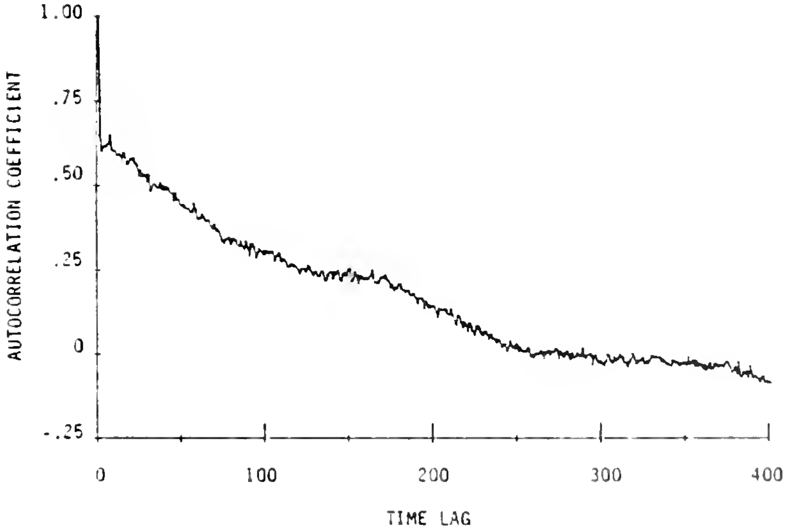

Fig. 4 Correlogram for the negative tick block price reaction index BPR_n

$$BPR(t) = m(t) + e(t)$$

where,

$BPR(t)$ = block price reaction index at time t;

$m(t)$ = trend component at time t;

$e(t)$ = residual (irregular) component at time t.

The trend component refers to broad movements extending over a considerable time period while the residual component is the irregular, fluctuating series remaining after the trend component has been removed. When trend has been appropriately identified and removed from a time series, the remaining residuals should be stationary. A time series is stationary if there is no systematic change in mean (no trend), if there is no systematic change in variance, and if strictly periodic variations have been removed.[54] In other words, the residual component is stationary if the expected value of the residuals is a constant and if the covariance between any two observations only depends on the time lag.[55]

In this section we attempt to identify the estimate the trend component in each BPR index so that it can be removed and analyzed. Subsequently, we consider alternative probability models that explain the behavior of the stationary residual component.

---

[54] Christopher Chatfield, The Analysis of Time Series: Theory and Practice (London: Chapman and Hall, 1975), p. 14.

[55] This is the definition for weak stationarity rather than strict stationarity. Strict stationarity requires that the joint distribution is the same for all time points. The term stationary, as used in this study will always refer to weak stationarity.

One can estimate trends in the BPR indices from two viewpoints. Either a regression model of causal variables for most of the six year period or a pure linear trend for a segment of the six year period.

Estimation of the Trend Component by a Causal Variable Model

The correlograms in Figures 3 and 4 suggested that the BPR indices are partly composed of a non-linear trend. Therefore, an approach that estimates the trend for the entire six year time span must be capable of identifying a non-linear trend.

One approach for estimating the non-linear trend component is a regression of the BPR indices on lagged causal variables with two characteristics. First, there should be an underlying, theoretical reason why the causal variable may be related to the BPR index. Second, the causal variables should have trend fluctuations similar (either in a positive or negative direction) to the BPR indices. The second criteria suggests that a variable may be related to the indices, but the variable is useless in a trend fitting model if it has a constant trend.

Variables Affecting Block Dealer Costs

Rejection of the initial null hypothesis suggests that the systematic behavior of block dealer costs may be explained by other variables. Inventory theory indicates how dealers price their services. Hence, the study of dealer costs over time involves the analysis of variables which affect the marginal costs of holding inventory. The following factors are postulated to affect both BPR_p and BPR_n the same way.

Daily Market Volatility. One would expect the BPR indices to be positively related to daily market volatility (MV) because a major risk of holding security inventories is the risk of unanticipated changes in capital value due to changing security prices. The operational definition for market volatility is:

$$MV(t) = \frac{|P_h(t) - P_l(t)|}{\frac{P_h(t) + P_l(t)}{2}}$$

where,

$MV(t)$ = market volatility for time t;

$P_h(t)$ = daily high of the Standard and Poors composite index for time t;

$P_l(t)$ = daily low of the Standard and Poors composite index for time t;

Data for the Standard and Poor's composite index were collected from the Stock Price Record.[56]

Daily Level of Trading Activity. The BPR indices are expected to be negatively related to trading activity because the dealer's inventory holding cost is a function of the holding period and heavy trading reduces the holding period. Several measures of trading activity are considered including the reported share volume on the NYSE(V_r).[57] Because the main source of supply and demand is other institutions,

---

[56] Standard and Poor's Corporation, ISL Daily Stock Price Record--New York Stock Exchange (issues for January 1972-December 1977).

[57] Included in the Stock Price Record, Ibid.

several measures concentrate on block trading activity: (1) block share volume on the NYSE (V_b); (2) daily number of plus tick blocks (B_p); (3) the daily number of negative tick blocks (B_n); (4) the daily number of total blocks (B_w); and (5) the ratio of block share volume to reported share volume (V_b/V_r).[58]

Daily Average Block Size. One would expect the BPR indices to be positively related to average block size (A) because with larger blocks dealers would have to position more securities which would increase their marginal inventory holding costs. Average block size is computed as:

$$A(t) = \frac{V_b(t)}{B_w(t)}$$

where,

$A(t)$ = average block size for time t;

$V_b(t)$ = block share volume during time t;

$B_w(t)$ = number of blocks traded during time t.

The following factors would probably not affect the two indices the same.

Proportion of Positive or Negative Tick Blocks. The BPR_p index is positively related to the proportion of positive tick blocks traded (B_p/B_w). The BPR_n index is positively related to the proportion of negative tick blocks traded (B_n/B_w). When anxious traders primarily tend to be on one side of the market, the dealer's inventory quickly

---

[58] Source: NYSE Large Blocks and Merrill Lynch, Pierce, Fenner and Smith, Inc.

deviates from his desired inventory levels and he will bid more aggressively on the passive side to bring his inventory levels in balance.

Although all of these variables are related to the BPR indices in terms of inventory theory, it is necessary to examine the time series plots of these variables to determine if the plots are consistent with the hypothesized relationship.

The market volatility plot seems consistent with the expected positive relationship so this variable (MV) is used. We hypothesized a negative relationship between the BPR indices and trading activity which is consistent with the plots. Still, because the several activity variables are similar, we used block share volume (V_b) as a broad block activity variable. The time series plot of the average block size was relatively flat so this variable was not used. The plot of B_n/B_w exhibits trend movements similar to BPR_n so is included in its model. In contrast, the plot of B_p/B_w appeared to have a negative relationship with BPR_p but was still included.

In sum, the following causal variable trend models are suggested by the theoretical relationships and the time plots:

$$BPR_p(t) = b_o + b_1\ MV\ (t-1) + b_2\ V_b\ (t-1) + b_3\ B_p/B_w\ (t-1) + e(t)$$

and,

$$BPR_n(t) = b_o + b_1\ MV\ (t-1) + b_2\ V_b\ (t-1) + b_3\ B_n/B_w\ (t-1) + e(t)$$

where,

$BPR_p(t)$ = positive tick block price reaction;

$BPR_n(t)$ = negative tick block price reaction;

MV $(t-1)$ = market volatility lagged one day;

V_b (t-1) = block share volume lagged one day;

B_p/B_w (t-1) = ratio of the number of positive tick blocks to total blocks, lagged one day;

B_n/B_w (t-1) = ratio of the number of negative tick blocks to total blocks, lagged one day;

e(t) = residual of the causal variable regression.

An additional method of trend determination is to split the time series into two segments and fit a separate trend component to each segment. A natural date for the time series split is May 1, 1975, when the security commission fee became fully negotiable. Because negotiated commission fees had a tremendous impact upon the exchanges and the security industry, a change in the basic trend process can be reasonably assumed to have occurred on May 1, 1975. Rather than estimating the above models with the complete 1972-1977 data set, the models are estimated for two separate time periods covering April 1972-April 1975 and May 1975-December 1977. The first three months of 1972 are not included, because data on the number of positive and negative tick blocks are not available.

The results of the causal trend fitting regressions in Table 4 suggests that the variables provide useful estimates for at least a portion of the trend component. However, the t-ratios and related statistics should be cautiously interpreted because successive observations are dependent in many of the time series. Therefore, the number of observations is <u>not</u> necessarily going to "improve" the statistics and an exact test of significance is <u>not</u> possible.

TABLE 4

ESTIMATED REGRESSION COEFFICIENTS FOR THE CAUSAL VARIABLE TREND COMPONENTS OF THE BLOCK PRICE REACTION INDICES

	BPR_p		BPR_n		BPR_p		BPR_n	
	April 1972-April 1975		April 1972-April 1975		May 1975-Dec. 1977		May 1975-Dec. 1977	
Regressors	Coefficients	T-Ratios	Coefficients	T-Ratios	Coefficients	T-Ratios	Coefficients	T-Ratios
Constant	0.665	(14.720)	0.519	(7.318)	0.692	(21.404)	0.734	(17.860)
Mkt. volatility (MV)	17.847	(13.304)	21.848	(15.486)	6.475	(4.865)	13.927	(8.906)
Blk. volume (V_b) (In millions)	-0.049	(-4.841)	-0.064	(-6.009)	-0.010	(-2.785)	-0.033	(-7.473)
Ratio of no. of pos. to total blks. (B_p/B_w)	-0.376	(-2.226)	--	--	-0.048	(-0.531)	--	--
Ratio of no. of neg. to total blks. (B_n/B_w)	--	--	1.087	(8.870)	--	--	0.241	(3.146)
	Sample size = 775 R^2 = 0.226 R^2 (adjusted)=0.223 F (3,771) = 75.232		Sample size = 775 R^2 = 0.373 R^2 (adjusted)=0.370 F (3,771) = 152.798		Sample size = 675 R^2 = 0.052 R^2 (adjusted)=0.047 F (3,671) = 12.285		Sample size = 675 R^2 = 0.260 R^2 (adjusted)=0.257 F (3,671) = 78.780	

The estimated coefficients of the four regression models may be used to estimate and plot the BPR trends. For example, Figures 5 and 6 illustrate how the BPR trends estimated by the regression models compare to the actual levels of the BPR indices. It appears that the regression models have successively captured the majority of the trend movement in the BPR indices.

The mean of each of the residual series generated by the causal variable regression is, by definition, equal to zero. Nevertheless, any remaining linear trend must be removed to produce stationary residual series. The slopes of the linear trends remaining in the residual series are listed in Table 5. Time series plots of the BPR_p residuals after linear trend removal indicate that much of the trend has been removed relative to the indices original time plots in Figures 1 and 2 and they appear to be relatively flat with the exception of the BPR_n index during 1973 and 1974.

Estimation of the residual series' autocorrelations also provides an indication of whether the trend has been successfully identified and removed. Table 6 lists the estimated autocorrelation coefficients for each residual series. The table demonstrates that much of the trend has been removed, because the autocorrelation coefficients are substantially below the autocorrelation coefficients of the original BPR indices. The important question is whether enough of the trend has been removed so that the remaining residual terms are relatively stationary.

The autocorrelation coefficients may be compared to their associated confidence limits to determine whether the time series is

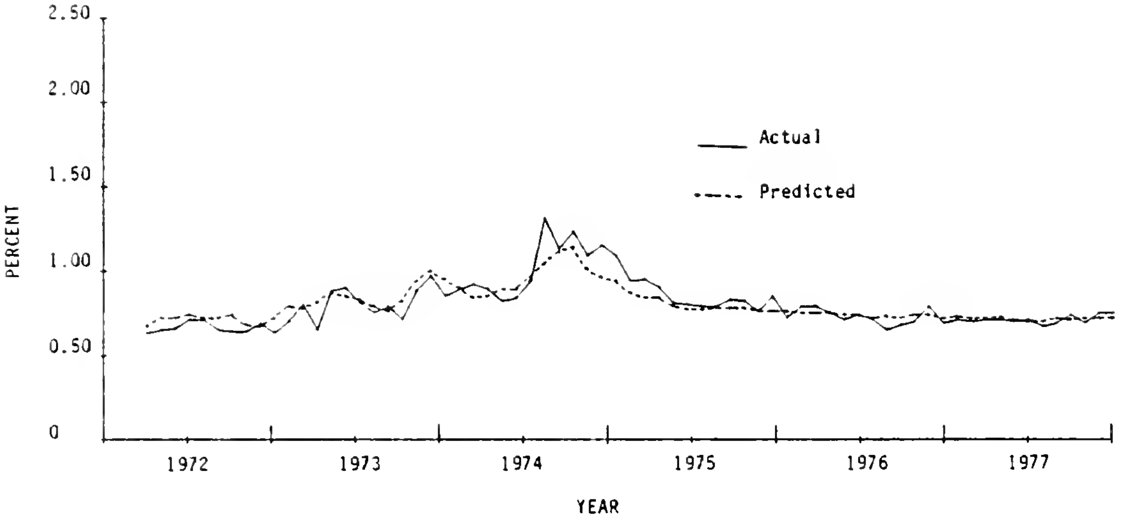

Fig. 5 Monthly causal variable model predicted BPR_p trend versus actual monthly BPR_p trend

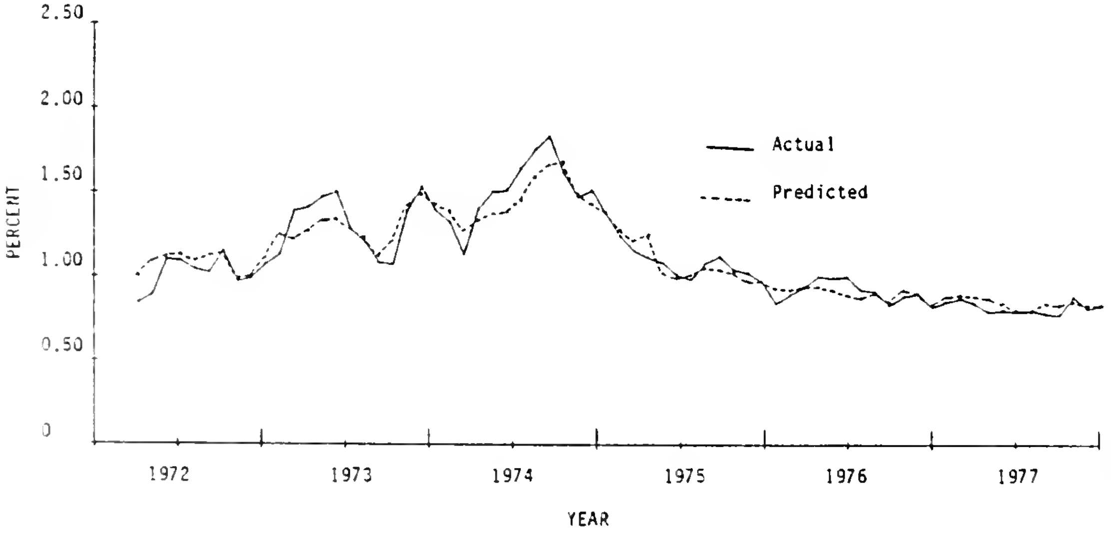

Fig. 6 Monthly causal variable model predicted BPR_n trend versus actual monthly BPR_n trend

TABLE 5

LINEAR TREND REMOVED FROM THE RESIDUALS OF THE CAUSAL VARIABLE REGRESSIONS

Linear Trend Components	April 1972-April 1975		May 1975-December 1977	
	BPR_p	BPR_n	BPR_p	BPR_n
Mean	0.0	0.0	0.0	0.0
Slope	.000251	.000115	-.000052	-.000100

TABLE 6

AUTOCORRELATION COEFFICIENTS OF THE BLOCK PRICE REACTION RESIDUAL COMPONENTS: CAUSAL VARIABLE MODELS

	April 1972-April 1975		May 1975-December 1977	
Lag	BPR_p	BPR_n	BPR_p	BPR_n
1	0.126**	0.202**	0.011	0.097**
2	-.043	.087*	-.055	.026
3	.016	.064	.060	.093**
4	.149**	.138**	.014	-.017
5	.057	.120**	.083*	.086**
6	-.004	.130**	-.040	.105**
7	-.018	.188**	-.005	.108**
8	-.016	.084*	.057	.049
9	.058	.093**	-.003	.032
10	.067	.095**	.030	.021
11	-.063	.093**	-.010	.005
12	.005	.134**	.051	-.001
13	.060	.090*	.022	.040
14	.109**	.029	.055	.028
15	0.021	0.085*	0.001	0.076

NOTE: The block price reaction residual components were generated by removing a linear trend from the causal variable model regression residuals.

*Significant at the .05 level.

**Significant at the .01 level.

stationary. The autocorrelation coefficients of a weak white noise time series are asymptotically normally distributed under weak conditions where the mean is approximately -1/T, the variance is approximately 1/T, and T is the total size of the time series.[59] This distribution theory can be used to construct confidence limits for the estimated autocorrelation coefficients. Recall that a stationary time series is characterized by autocorrelation coefficients that approach zero at reasonably short lags so their autocorrelation coefficients should lie between the confidence limits after a reasonably short lag. The results in Table 6 suggests that the time series are all stationary except the BPR_n residuals for April 1972-April 1975 because a substantial number of the coefficients are significant for this series.

Pure Linear Trend Models for July 1976-December 1977

A pure linear trend component model is defined as a series that has a linear trend component. Rather than estimating a non-linear trend for the entire BPR series, the series can be examined to determine whether a segment of the time series is approximately linear. This approach is advantageous since it does not introduce any other variables to explain trend. Instead, the method relies on the variable itself to determine the trend component. Visual inspection of the BPR time plots in Figures 1 and 2 indicates that both indices have relatively flat trends for the period mid-1976 through 1977. Even the causal regression models predicted flat trends for this time segment.

---

[59] Chatfield, The Analysis of Time Series: Theory and Practice, p. 62-63.

TABLE 7

AUTOCORRELATION COEFFICIENTS OF THE BLOCK PRICE REACTION RESIDUAL COMPONENTS: JULY 1976-DECEMBER 1977 PURE LINEAR TREND MODELS

Lag	BPR_p	BPR_n
1	0.113*	0.139**
2	.011	.017
3	.065	.101*
4	-.044	-.030
5	.093	.082
6	.035	.161**
7	-.035	.108*
8	-.066	.035
9	.049	.055
10	.070	.116*
11	.032	.004
12	.051	.022
13	.090	-.010
14	.047	-.014
15	-0.020	0.004

NOTE: The block price residual components were generated by removing a linear trend from the original time series.

*Significant at the .05 level.

**Significant at the .01 level.

The BPR indices for July 1976-December 1977 were examined to determine whether removal of pure linear trends left stationary residual series. An analysis of the plots suggest that <u>both series are stationary after linear trend removal</u> and the assumption of stationarity is further supported by the autocorrelation estimates listed in Table 7 which approach zero over relatively short time lags.

In sum, both BPR indices have non-linear trend components over the entire six year time span. Much of the non-linear trend may be explained by a combination of a causal variable regression, a split of the data set as of May 1, 1975, and a linear slope remaining in the residual terms. The resulting residual series were all stationary except for BPR_n during the time period April 72-April 75. Finally, a pure linear trend component was estimated for both indices during July 1976-December 1977 and both of the residual series were stationary after removal of trend.

TIME DOMAIN MODELS FOR THE RESIDUAL COMPONENT OF THE BPR INDICES

Once the trend components are removed from the original BPR indices, the remaining residual components are stationary in mean and variance. From an economic standpoint, an important question is whether the stationary residual is white noise. Although prior tests indicated that the <u>original BPR indices are not white noise, the question remains of whether the residual component of the BPR indices is white noise</u>. If the residual component <u>is</u> white noise this implies that successive values are uncorrelated and <u>prediction of future BPR values can be made by simple forecasts of only the trend component</u>. Alternatively, if the residual component is _not_ white noise this suggests that past observations of the residual process provides useful information and _prediction of the BPR index is enhanced by both a model of the trend component and a probability model of how the residual components behaves over time_.

This section examines the BPR residual components by first determining whether the residual series are white noise and then examining the non-white noise residual series to build appropriate time series models.

White Noise Tests

To determine whether the residual series are white noise two similar approaches are used which depend on the estimated autocorrelation coefficients. The first white noise test examines whether the individual autocorrelation coefficients are statistically different from zero assuming the distribution of autocorrelation coefficients for a white noise process. Under a 95 percent confidence limit, one "significant" autocorrelation coefficient out of twenty is expected under the assumption of white noise. If the series is not white noise, there may be several significant autocorrelation coefficients over the first twenty time lags.

The second test of white noise is the Kolmogorov-Smirnov test which considers the goodness of fit between the hypothesized distribution function for white noise and the empirical distribution function for a _set_ of autocorrelation coefficients.[60] The hypothesis of white

---

[60] Robert V. Hogg and Elliot A. Tanis, _Probability and Statistical Inference_ (New York: MacMillan Publishing Co., 1977), p. 281-83.

noise is rejected if the empirical distribution function is sufficiently different from the white noise distribution function. While the first test checks each individual autocorrelation coefficient, the Kolmogorov-Smirnov test examines several autocorrelation coefficients at the same time.

The five following stationary residual series were tested for white noise behavior: BPR_p for April 1972-April 1975; BPR_p and BPR_n for May 1975-December 1977; and BPR_p and BPR_n for July 1976-December 1977. The first three series were derived from the causal model and the last two series resulted from the pure linear trend models.

The autocorrelation coefficients for the five series are given in Tables 6 and 7. The BPR_n residual series for May 1975-December 1977 are clearly not white noise, because they each have 5 out of 15 significant coefficients based upon 95 percent confidence limits. In contrast, the BPR_p residuals for the same two time periods are presumably white noise, since they have only 1 out of 15 significant coefficients. A clear interpretation for the BPR_p residuals of April 1972-April 1975 is difficult, because there were only 3 significant coefficients out of the 15 examined. In this case, the Kolmogorov-Smirnov test can provide additional insight.

The Kolmogorov-Smirnov test results in Table 8 are based upon the autocovariances at all lags up through lag seven. The statistic is compared to critical points calculated for both 5 percent and 1 percent significance levels. The results indicate that all BPR_p residuals are white noise, but all the BPR_n residuals are not white noise.

TABLE 8

KOLMOGOROV-SMIRNOV STATISTICS FOR TESTING THE HYPOTHESIS OF WHITE NOISE BASED ON THE BLOCK PRICE REACTION RESIDUAL COMPONENTS

Residual Component	Kolmogrov-Smirnov Test Statistics	Decision Based on a Five Percent Critical Point Equal to .481	Decision Based On a One Percent Critical Point Equal to .576
BPR_p (April 72-April 75)	0.383	Accept	Accept
BPR_p (May 75-Dec. 77)	.225	Accept	Accept
BPR_n (May 75-Dec. 77)	.675	Reject	Reject
BPR_p (July 76-Dec. 77)	.337	Accept	Accept
BPR_n (July 76-Dec. 77)	0.634	Reject	Reject

NOTE: The test statistics were calculated based upon autocovariances at all lags up through lag seven.

In sum, a prediction of the BPR_p index should be based entirely on a simple estimate of its future trend component. In contrast, a prediction of the BPR_n index should be based on both the trend component and a time series model of the residual component.

Autoregressive Models of the BPR_n Residual Component

Because the residual components of the BPR_n index are not weak white noise, this subsection focuses on fitting a suitable model to the residual series. It is assumed that a given value of the BPR_n residual series depends on its immediate past values combined with a random error. This implies that factors which influence block dealer cost decisions may have a systematic dependence on past history and the price impact of new information may produce a "disturbance term" or random error on any given day. A time domain model that is consistent with this physical interpretation of the BPR_n residual component is the following autoregressive process

$$e(t) = \sum_{s=1}^{p} a_s e\,(t-s) + Z\,(t)$$

where,

$e(t)$ = a stationary residual time series;

$z(t)$ = a weak white noise time series;

a_s = the autoregressive coefficient at time lag s;

p = the order of the autoregressive process.[61]

---

[61] A finite order autoregressive process is assumed to adequately approximate the underlying stochastic process primarily because of the economic situation. In addition, this assumption may be supported by the duality between the autoregressive and moving average processes. Durbin pointed out that a high order autoregressive process may be fitted to a moving average process with only a small error. See Maurice Kendall, Time Series (New York: Hafner Press, 1976), p. 161.

Fitting an autoregressive scheme to the BPR_n residual series involves two related questions: (a) what is the order of the process and (b) what are the estimated autoregressive coefficients of the process.

To determine the order of an autoregressive process one fits processes of progressively higher order to the residual series and calculates Quenouille chi-square statistics at each order.[62] The statistics establish whether the given order of p is large enough so that higher orders do not significantly improve the fit. If a given order is _not_ high enough, then the statistic at the next highest order is checked. This procedure is continued until a particular autoregressive order can be accepted according to the Quenouille chi-square statistic. The autoregressive coefficients for any given order are calculated by a recursive solution to the Yule-Walker equations.[63]

Table 9 lists the Quenouille test statistics for the BPR_n residual components covering both the May 1975-December 1977 and the July 1976-December 1977 time periods. The null hypothesis for a given order p is tested against the alternative hypothesis which states that the order is from (p+2) to (p+5). The results of the test statistics indicate that the autoregressive order of both residual series is 6.[64]

---

[62] M. H. Quenouille, "Approximate Tests of Correlation in Time Series," _Journal of the Royal Statistical Society_, B11-68 (1949).

[63] Chatfield, _The Analysis of Time Series: Theory and Practice_, p. 68.

[64] A visual inspection of the residual variances plotted against order also supports the acceptance for an order of 6.

TABLE 9

QUENOULLI CHI-SQUARE TEST STATISTICS FOR THE RESIDUAL COMPONENT OF THE NEGATIVE TICK BLOCK PRICE REACTION INDICES

Hypothesized Autoregression Order (P)	BPR_n (May 75-Dec. 77)		BPR_n (July 76-Dec. 77)	
	Test Statistics for Alternative Orders (p+2) through (p+5)[a]	Decision at the Five Percent Significance Level	Test Statistics for Alternative Orders (p+2) through (p+5)[a]	Decision at the Five Percent Significance Level
1	15.702	Reject	13.428	Reject
2	18.428	Reject	15.284	Reject
3	12.074	Reject	16.196	Reject
4	17.927	Reject	15.704	Reject
5	11.239	Reject	10.917	Reject
6	4.939	Accept	6.931	Accept

[a] Each statistic is tested against a chi-square distribution with four degress of freedom.

The autoregressive models of the two BPR_n residual components may be expressed as

A) BPR_n residual component for May 1975-December 1977

$e(t) = .0938\ e(t-1) + .0037\ e(t-2) + .0856\ (t-3) - .0449\ e(t-4) + .0825\ e(t-5) + .0825\ (t-6) + z(t)$,

B) BPR_n residual component for July 1976-December 1977

$e(t) = .1395\ e(t-1) - .0185\ e(t-2) + .0968\ (t-3) - .0709\ e(t-4) + .0791\ e(t-5) + .1297\ (t-6) + z(t)$.

Forecasting

Forecasting future block dealer costs is a particularly important problem for institutional block traders. The BPR_n index can be forecasted by combining a projection of the trend component and the residual component. A forecast of BPR_n for s steps into the future may be expressed as

$$\hat{BPR}_n\ (t+s) = \hat{m}\ (t+s) + \hat{e}\ (t+s)$$

where,

$\hat{BPR}_n\ (t+s)$ = the block price reaction on negative tick blocks for day (t+s) forecasted on day t;

$\hat{m}\ (t+s)$ = the projection of the trend component for day (t+s) forecasted on day t;

$\hat{e}\ (t+s)$ = the projection of the residual component for day (t+s) forecasted on day t;

s = lead time.

Either the causal regression trend model or the pure linear trend model project future values for the <u>trend component</u>. The <u>residual</u>

component is predicted by the estimated autoregressive models. In general, the linear least square predictor for an autoregressive process of order p is

$$\hat{e}(t+s) = \sum_{k=1}^{s-1} a_k \hat{e}(t+s-k) + \sum_{k=s}^{p} a_k e(t+s-k).$$

The first term on the right-hand side of the equation substitutes predictors for the unknown future residual values, while, the second term uses the known residual values. The equation provides the best point estimate of the future residual value. In addition, the coefficients can be used to calculate a prediction variance for each forecasted residual value.

Table 10 provides forecasting example for the BPR_n index by applying the trend component and residual component models from the July 1976-December 1977 time period. Given the data available on the last day of 1977, forecasts are made for the first 10 days in 1978. The trend component is estimated by extrapolating the negatively sloped linear trend derived earlier. The forecast for the residual component is the linear least square estimator for the given autoregressive process. Prediction intervals are constructed by first summing the trend components and residual components to get point predictions and prediction variances are used to calculate 50 percent and 95 percent prediction limits. Notably, when the prediction intervals are compared to the actual 1978 observations, 6 out of 10 fall in the 50 percent prediction interval and 10 out of 10 fall in the 95 percent prediction interval.

TABLE 10

EXAMPLE OF A TEN DAY FORECAST FOR 1978 VALUES OF THE NEGATIVE BLOCK PRICE REACTION INDEX BASED UPON 1977 OBSERVATIONS

Lead Time In Days	Estimated Value for the Trend Component	Linear Least Square Predictor of the Residual Component	Prediction Variance for the the Residual Component	50 Percent Confidence Prediction Interval	95 Percent Confidence Prediction Interval	Actual Observation In 1978
1	0.792164	-0.063087	0.01264	0.653178, 0.804978	0.508678, 0.949478	0.90
2	.791900	.018502	.01289	.733802, .887802	.590002, 1.032902	.79
3	.791636	-.039209	.01290	.676327, .829727	.530427, .975627	.88
4	.791372	-.087315	.01304	.706957, .830127	.529227, .976827	.87
5	.791108	-.010239	.01317	.703369, .858369	.555969, 1.005769	.85
6	.790844	-.002557	.01332	.710387, .866187	.562087, 1.014487	.85
7	.790580	.004813	.01342	.717193, .873593	.568293, 1.022493	.81
8	.790316	.000458	.01342	.712574, .868974	.563674, 1.017874	.79
9	.790052	.005210	.01342	.717062, .873462	.568162, 1.022362	.91
10	0.789788	0.000394	0.01342	0.711982, 0.860382	0.563082, 1.017282	0.82

In summary, this section demonstrated that residual component of the BPR_p index is weak white noise which suggests that forecasts of the BPR_p index should be based entirely on a projection of the trend component. In contrast, the white noise hypothesis was rejected for the residual component of the BPR_n index which means a model of the residual component for the BPR_n index is beneficial. An autoregressive process of order 6 was found to fit the BPR_n residual components for both May 1975-December 1977 and July 1976-December 1977. Given the trend models and the autoregressive models, prediction intervals were constructed for the BPR_n index.

FREQUENCY DOMAIN MODELS FOR THE RESIDUAL COMPONENTS OF THE BPR INDICES

A growing body of experience indicates that the analysis of time series is aided by a consideration of both time properties and the frequency properties of the data.[65] The prior section discussed the autocorrelation function which considers the evolution of the BPR residuals through time. In this section, the spectral density function is introduced to examine the frequency properties of the BPR residuals.[66] In essence, spectral analysis describes how variation in a time series may be accounted for by cyclical components at different frequencies.

---

[65] See Clive W. J. Granger and M. Hatanaka, Spectral Analysis of Economic Time Series (Princeton, New Jersey: Princeton University Press, 1964) or Gwilym M. Jenkins and Donald G. Watts, Spectral Analysis and Its Applications (San Francisco: Holden-Day, 1968).

[66] Theoretically, either the spectral density function or the autocovariance function can be deduced from one another. However, additional information is gained by computing both functions, because each form presents its own interpretation of the data.

An essential element of spectral analysis is *frequency* which is defined as the number of cycles (periods) per unit of time. For example, if a time series has a frequency of .2 cycles per day, then it takes 5 days to complete one *full* cycle. However, the variation of most economic time series *cannot* be represented by a strict periodic function, because the amplitude and phase of economic cycles change *irregularly* over time. Yet, many economic time series have *regular* fluctuations since the average length of the series' oscillations remain constant. Fortunately, the spectral method provides a mathematically natural approach to this mixture of regularity and non-regularity. The method allows a *broader* interpretation of cycles since fluctuations do *not* have to be perfectly regular. The method can reflect any tendency in the residual series for periodic variations to occur in particular frequency *ranges*. In other words, cycles with nearly all the same length periods may be associated with a *single range of frequencies* (sometimes referred to as a *frequency band*).

Several studies have applied the spectral technique to the analysis of stock market prices.[67] The research focused on the estimated spectrums of stock market price series. *Estimated spectrums* are graphical representations of the estimated spectral density function against frequency as abscissa.

---

[67] See Clive W. J. Granger and Oskar Morgenstern, *Predictability of Stock Market Prices* (Lexington, Massachusetts: Heath Lexington Books, 1970); For recent applications, see Jimmy E. Hilliard, "The Relationship Between Equity Indices on World Exchanges," *Journal of Finance* 34 (March 1979): 103-115 and Peter D. Praetz, "Testing for a Flat Spectrum on Efficient Market Price Data," *Journal of Finance* 34 (June the 1979): 645-58.

This study is concerned with the possibility of a systematic pattern in block dealer costs. Prior results indicated that the BPR_p residuals were random, but that the BPR_n residuals could be modeled as an autoregressive process. In this section we analyze both BPR residual series to search for any significant cyclical behavior in the data. While the absence of cycles indicates random behavior, significant cycles in a BPR index would demonstrate a systematic, non-random pattern where the future dealer cost is related to the past costs.

The estimated spectrums of the BPR_p residuals and the BPR_n residuals are illustrated in Figures 7 and 8. Data for the period July 1976-December 1977 were used for calculating both spectrums. The spectrums were constructed by first deriving the periodograms by a fast Fourier transform, and then smoothing the periodogram by a Daniell window.[68] The Daniell approach smooths the periodogram by simply grouping the periodogram ordinates in sets of size m and then finding their average value. An m of size 31 was used in both Figures 7 and 8.[69]

The most important feature of the estimated spectrum is whether there are any peaks. The band of frequencies associated with the peak indicates a substantial cycle in the data.[70] Interpretation of the spectrum assumes the total area under the curve is equal to the

---

[68] Chatfield, The Analysis of Time Series: Theory and Practice, p. 143.

[69] Several spectrums were calculated at alternative m-windows. An m=31 appeared to illustrate the major cycles important to this analysis.

[70] The frequencies of the spectrum range from zero to π. π corresponds with a half cycle per time unit, therefore, the abscissa values range from zero to .50 cycles per day.

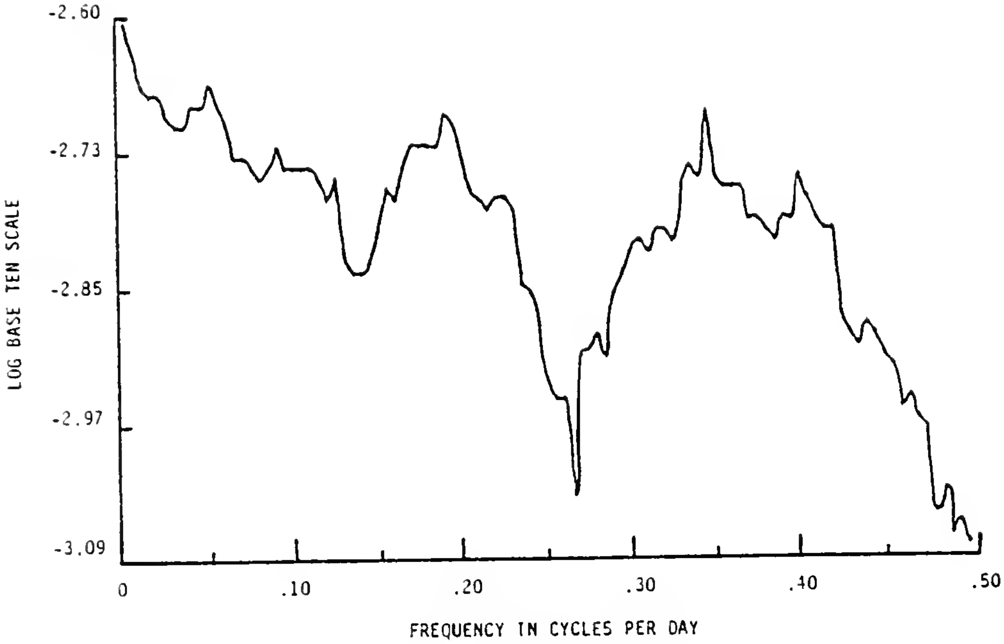

Fig. 7 Estimated spectrum for the positive tick block price reaction index BPR_p (m=31)

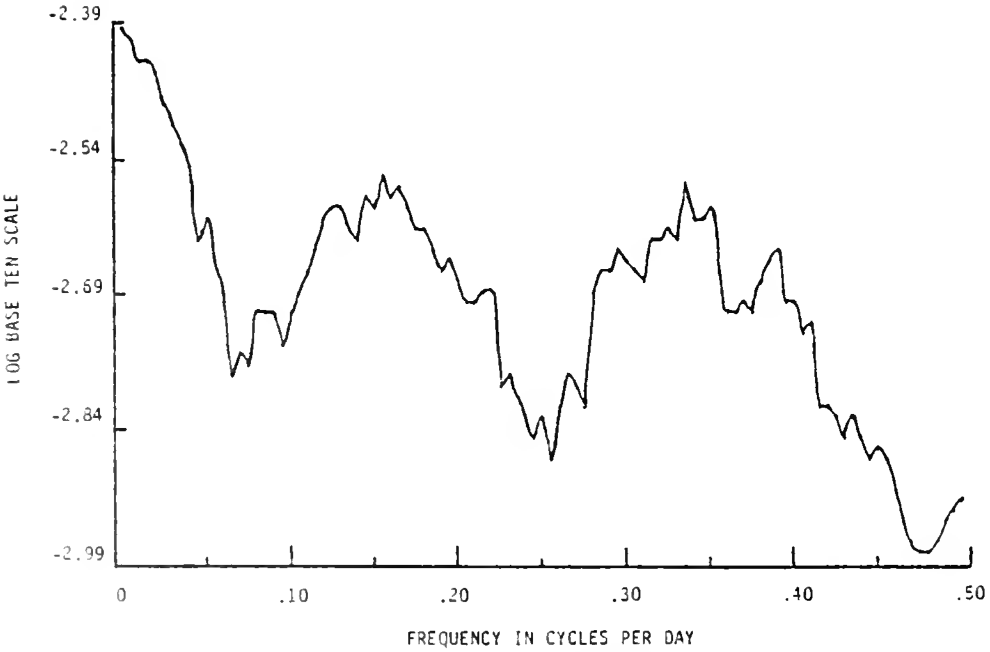

Fig. 8 Estimated spectrum for the negative tick block price reaction index (m=31)

variance of the time series. Therefore, a peak in the spectrum indicates an important contribution to the total variance at the frequencies in the appropriate region. In contrast, a horizontally flat spectrum suggests that all frequencies contribute equally to the total variance, and there are no significant cycles (e.g., a white noise time series produces a flat spectrum).

Peaks in the spectrum may be tested for significance against a null hypothesis which states the underlying time series is white noise--i.e., the true spectral density function is equal to what would be expected under white noise. The alternative hypothesis states that the true spectral density has a peak which is greater than the flat white noise spectral density function. That is,

$$H_o: \quad f(\theta_i) = f_o(\theta)$$
$$H_1: \quad f(\theta_i) > f_o(\theta)$$

where,

$f(\theta_i)$ = the true spectral density function at frequency θ_i;

$f_0(\theta)$ = the constant spectral density function assuming white noise behavior.

The null hypothesis is rejected at the 5 percent significance level if

$$\ln \hat{f}_m(\theta_i) > \ln f_0(\theta) + 1.645/\sqrt{m}$$

where,

$\ln \hat{f}_m(\theta_i)$ = the natural logrithm of the m-windowed spectral estimator at frequency θ_i;

$\ln f_0(\theta)$ = the natural logrithm of the constant spectral density function assuming white noise behavior. This is calculated by dividing the variance of the process by the value of π;

m = the number of periodogram coefficients averaged, which is the size of the Daniell window.

The estimated spectrum for the BPR_p residuals in Figure 7 illustrates several features. First, the importance of the low frequencies suggests that the series contains long trend fluctuations, although the length of the data is insufficient to attempt to describe these fluctuations more accurately. Apparently there are two peaks at frequencies of .190 and .345 cycles per day. Since the variance of the series is equal to .01053 and $m=31$, the peaks are significant at the 5 percent level if the natural logs of their respective spectral estimates are greater than -5.403. The natural logs of the spectral estimators are -5.455 at frequency .190 and -5.455 at frequency .345 (where frequency is measured in cycles per day). Neither peak is significant, therefore, the BPR_p residuals do not have any important cycles. These results reaffirm the prior findings that the BPR_p residuals are white noise.

The estimated spectrum for BPR_n residuals in Figure 8 has some trend illustrated by the low frequency spectrum. In contrast, the two peaks of the BPR_n residuals at frequencies .155 and .335 appear to be more pronounced. The variance of the BPR_n residuals of .01343 produces a test statistic of -5.160 and -5.225 at the 5 percent and 10 percent significance levels. The natural logs of the spectral estimates are -5.132 at frequency .155 and -5.192 at frequency .335. Notably, the peak at frequency .155 is significant at the 5 percent level indicating a substantial cycle of approximately 6 days in length. The 3 day cycle represents the first harmonic of the 6 day cycle which suggests that the important cyclical movement is the 6 day cycle.[71]

In sum, the spectral analysis of the BPR indices indicates the following findings. First, both series have some low frequency movement remaining. Second, the BPR_p residual series does not have any cyclical behavior, hence, the series has no systematic dependence on past values. In contrast, the BPR_n residual series has a significant 6 day cycle with a first harmonic 3 day cycle.

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Summary

The primary task of this study was to describe and explain the intertemporal behavior of block dealer costs. The analysis initially determined whether expected block dealer costs behave in a systematic manner over time. Second, the analysis tested several exogenous market factors which could influence the intertemporal behavior of the block dealer costs. Such an analysis is important because it is the first study to add the dimension of time to the existing dealer behavior theory. In addition, this study contributes additional information on the block securities market which has become extremely important because of its rapid growth whereby it is a major component of our secondary securities market. Further, the study results should assist investment managers who recognize the need to integrate a temporal

---

[71] Harmonics, which are multiples of the fundamental frequency, simply indicate the non-sinusoidal character of the main cyclical component.

dealer cost component into their institutional trading policy. Finally, this study should help in the development of a model of the block trading mechanism which can be used for monitoring security market transaction efficiency over time.

The first section discussed the need for dealer services in an imperfect transaction market and considered how dealers are compensated. A discussion of prior studies demonstrated that cross-sectional dealer costs were a function of security factors (i.e., volume of trading and risk), market factors (i.e., the marketplace and dealer competition), and transaction order factors (i.e., the size of the trade and the active side of the trade). In contrast to these preceding studies, this investigation added the dimension of time by examining the time series behavior of dealer costs. If dealer costs behave systematically over time, one could use past information to explain and predict future dealer costs.

This study focused on the behavior of block dealers after a discussion of the rapidly growing block transactions market which differs from the non-block market. Since the block dealer cost is unobservable this study utilized the block price reaction (BPR) indices as the operational measures of the block dealer costs. The BPR indices were constructed from the average absolute values of daily percentage price changes on purchase and sale block transactions.

The extensive time series analysis of the BPR series attempted to determine if the series were similar to a white noise process. If they were not, then the intent was to identify the regular, systematic pattern and possibly explain it in terms of some other market series suggested by dealer cost theory.

Conclusions

On the basis of the empirical tests, the following conclusions regarding the BPR indices are in order:

BPR_n Index

1. The block dealer cost for negative tick blocks clearly behaves in a systematic pattern over time. The runs test and the correllogram both indicate substantial non-random behavior--i.e., the BPR_n series is not weak white noise.

2. The behavior of the BPR_n index can be broken down into a trend component and a residual component. Much of the trend movement can be explained by the following lagged causal variables: market volatility, block share volume, and the ratio of negative tick blocks to total blocks.

3. The stationary residual component can be estimated in two alternative ways. One method is to derive the residuals from the causal variable regression and then remove a linear trend. Another method removes the pure linear trend from a segment of the time series that is relatively flat.

4. The behavior of the BPR_n residual component is not weak white noise, consequently, probability models can be constructed based upon the systematic behavior of the residuals. A time domain analysis indicates that the BPR_n residual component may be modeled as an autoregressive scheme of order 6. A spectral analysis demonstrates that the residual series contains a major six day cycle.

5. The BPR_n index can be forecasted by <u>combining</u> a projection of the trend component (using either the causal variable model or pure linear trend model) with a prediction of the residual component (using either the autoregressive model or the six day cyclical movement).

BPR_p Index

1. Dealer costs for positive tick blocks produce a very weak systematic pattern over time. Although the BPR_p index exhibits some gradual trend movements, the fluctuations are weak compared to the BPR_n index. The runs test supports the notion of randomness, but the correlogram indicated some trend movement. Hence, the alternative hypothesis is accepted if one considers the entire six-year time span.

2. The small trend movement can primarily be explained by lagged values of market volatility, block share volume, and the ratio of the number of positive tick blocks to the total number of blocks.

3. The residual component of BPR_p is weak white noise with no significant cyclical fluctuations.

4. Forecasts of BPR_p should be based entirely on the trend component, because of the white noise residual component behavior.

Implications

The results of this study has implications for institutional traders, government agencies, and future research.

Institutional Traders

Institutional traders should consider the timing of the block transaction as an additional determinant of the large, unpredictable dealer cost. The institutional investment manager must weigh the anticipated transaction cost against the anticipated advantage of any trade. Therefore, better transaction cost forecasts will improve the investment managers decision making.

The timing dimension is most important for the institutional trader who wants to sell a block. His dealer cost estimate must be based upon security factors, market factors, transaction factors, and temporal factors. Specifically, he should estimate both the trend component and the residual component of the price impact. An examination of recent market volatility, block share volume, and the proportion of negative tick blocks provides a well-founded trend estimate. Then, the institutional block trader can predict the residual component by using the last six observations of the BPR index in combination with either the suggested autoregressive model or an amplitude estimation model of the 6-day cycle. Furthermore, a prediction interval can be constructed to focus the necessary information needed for his trading decision.

The institutional block trader should not be concerned with day-to-day block volume changes. Rather, a long-term trend estimate of trading activity is sufficient.

In summary, the findings of this study suggest a manager can reduce his transaction costs by monitoring the variation in dealer costs and by remaining flexible regarding the timing of a block trade if possible.

In addition, investment managers must judge the transaction costs incurred after a block trade. Specifically, institutions currently rate their broker-dealer on block transactions occurring in different time periods. The results of this study indicate that when conducting such an analysis, the intertemporal behavior of the block dealer costs should be considered.

Governmental Agencies

Market observors charged with guiding changes in the securities industry should contemplate the time dimension when they gauge security dealer costs because the results of this study indicate that the expected dealer costs change over time. As the National Market System evolves, the SEC should observe the intertemporal variation of block dealer costs to determine the effects of their policy changes.

Future Research

Cross-sectional studies on dealer costs must be particularly careful in matching the data according to time. Studies which compare dealer costs on transactions occurring in distinctly different time periods may distort their findings.

THE MONETARY RETURNS TO HIGHER EDUCATION:
ARE THEY WORTH THE INVESTMENT COSTS?

Walter W. McMahon, Professor of Economics
and Education, Department of Economics
Alan P. Wagner, Purdue University

#619

College of Commerce and Business Administration
University of Illinois at Urbana-Champaign