A TEST OF ALLOCATIONAL MARKET EFFICIENCY IN TAKEOVERS
USING TOBIN'S q THEORY OF INVESTMENT

DISSERTATION

Presented to the Graduate Council of the
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By

KeeHo Kim, MBA
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The primary purpose of the study was to investigate whether takeover markets are allocationally efficient using Tobin's q as the variable which summarizes the investment opportunities of firms. Chapter I presented the purposes, hypotheses, methodology, and limitations of the study. The two hypotheses proposed were as follows: Acquiring firms' q should be significantly higher than that of control firms, on average, and target firms' q should be significantly lower than that of control firms, on average.

Chapter II presented the review of literature on takeovers and theory of investments. Chapter III presented the research design adopted to test the above hypotheses. The methodology to calculate q-values and methods to reduce the bias which may result from choice-based sampling were also given. A paired comparison t-test was employed to test the hypotheses. Sample firms were selected from the COMPUSTAT RESEARCH and COMPUSTAT INDUSTRIAL tape.

Chapter IV presented the results of the study. To calculate market value of bonds, bond ratings were predicted for those whose ratings were not available. To calculate average value of q, both equal- and market-value weights
were used. Shapiro-Wilk's statistic was used to test normality of q. After the values of q were tested for normality, paired comparison t-tests were performed.

The main results of the study are as follows: 1) Tobin's q-values were generally low compared to the equilibrium value of one, and the values ranged from the mid .70's to high .90's. 2) The responses to the market trend of q were not markedly different from each other. 3) The variable lnq satisfied the most important assumption of t-test--normality. 4) A paired comparison t-test showed that the average value of log-transformed q values for the acquiring firms was significantly higher than the average value of the control firms. 5) An acquired firm group and its control group do not have significantly different values of q. 6) The variable lnq alone was not enough to be used in the prediction of acquirers.

Chapter V concluded that the behavior of acquirers is consistent with the implication of allocationally efficient takeover markets. On the other hand, target firms' behavior is not.
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GLOSSARY OF FREQUENTLY USED SYMBOLS

Effort has been made to use consistent notation throughout. However, \( F \) and \( l \) each imply two different meanings. \( F \) denotes a production function in Chapter II; in Chapter III \( F \) means a cumulative distribution function of a random variable. While \( l \) indicates lagrangian function in Chapter II, \( l \) means likelihood ratio function in Chapter III. Superscripts and subscripts are sometimes used together to convey particular meanings.

* * * * * A * which superscribes a variable denotes its optimized value

' ' ' ' ' A ' denotes first derivative

' ' ' ' ' A " denotes second derivative

\( a \) . . . . . Intercept in a regression or probit equations

\( \alpha \) . . . . . The ratio of the capital gain equivalent to a dollar of dividend

\( b \) . . . . . Slope coefficient in a regression or probit equations

\( c \) . . . . . The implicit rental cost of capital

\( co \) . . . . . Abbreviation for control group of firms

\( \bar{d} \) . . . . . The average difference of \( m_{\text{ex}} \) and \( m_{\text{co}} \)

\( \delta \) . . . . . The rate of depreciation

\( \dot{\cdot} \) . . . . A dot over a variable means its time derivative
e . . . . . Error term in a regression or probit equations

ex . . . . . Abbreviation for experimental group of firms

f . . . . . Fraction of estimated $NB_t$ to $\sum_{j=0}^{n=1} NB_{t-j}$

g . . . . . Real price of investment goods (per unit)

\hat{\Lambda} . . . . A hat over a variable means its estimated value

hinv_{j} . . . . Estimated value of inventory which was acquired at year j

i . . . . . The rate of investment tax credit

k . . . . . The ratio of capital to variable input (K/L)

l . . . . . Lagrangian function in chapter II, however likelihood ratio function in chapter III

\lambda . . . . Shadow price

m . . . . . Average level of Tobin's q in the control group

m . . . . . Average level of Tobin's q in the experimental group of firms

mvb(t,t-j) . . Market value of debt $1 which was issued new at t-j

\omega . . . . Real wage rate

p . . . . . Price of output

\Pi . . . . . Firm's profit

q . . . . . Tobin's average q

q . . . . . Tobin's marginal q
\( r \) . . . . Discount rate
\( \rho \) . . . . Yield to maturity
\( \theta \) . . . . Average effects attributable only to experimental firm
\( s^2 \) . . . . Sample variance
\( \psi \) . . . . Hayashi's installation cost function
\( \sigma^2 \) . . . . Population variance
\( t \) . . . . Time
\( u \) . . . . Price of investment goods
\( w \) . . . . Price of variable input (wage)
\( x \) . . . . Independent or confounding variables
\( y \) . . . . Dependent variable which takes 0 or 1 depending on the occurrence of an event (takeovers)

\( AiCINV \) . . Adjusted value of CINV for \( i^{th} \) time
\( B \) . . . . The level of total recorded book debt
\( BL \) . . . . The level of debt maturing more than one year later
\( B1 \) . . . . The level of debt that will mature within a year
\( C \) . . . . Adjustment cost function
\( CAR \) . . . . Cumulative average residual
\( CINV \) . . . . Year to year changes in HINV
\( D \) . . . . The level of depreciation
\( Dq \) . . . . Difference of \( q \) between experimental and control firm
Dlnq . . . . Difference of log-transformed q between experimental and control firm
Dqade . . . . Difference of adjusted q with equal weights between experimental and control firm
Dqadm . . . . Difference of adjusted q with market weights between experimental and control firm
Dqadeln . Difference of log-transformed adjusted q with equal weight between experimental and control firm
Dqadmln . Difference of log-transformed adjusted q with market weight between experimental and control firm

F . . . . . Production function in Chapter II; in Chapter III, F will be denoted as cumulative distribution function of a random variable

$F_L$ . . . . A letter which subscribes function $F$ means first partial derivative with respect to $L$

$F_{LL}$ . . . . Letters which subscribe function $F$ mean second partial derivative with respect to $L$

H . . . . . Hamiltonian function
HINV . . . . Reported historical value of inventories
HNP . . . . . Reported historical value of net plant
I . . . . . Level of investment
K ........ Capital stock
K* ....... The long run desired stock of capital
L .......... Level of variable input (labor)
MVB ....... Estimated market value of bond
NB_i ........ Estimate of new long-term debt issued at time i
P .......... Probability
Q .......... Level of output
R .......... Firm's net receipt
RC .......... Replacement cost of a firm
RNP ....... Replacement cost of net plant
RINV ....... Replacement cost of inventories
U .......... Corporate tax rate
W .......... Wealth or present value of a firm

xi
CHAPTER I
INTRODUCTION

Background

Three different concepts of capital market efficiency are often cited in the literature (2, pp. 150-180; 8, pp. 285-287). Those concepts are informational efficiency, allocational efficiency, and operational efficiency. From the viewpoint of society as a whole, allocational efficiency is the most important. Informational efficiency is a necessary, but not a sufficient, condition for allocational efficiency (2, pp. 145-146). An allocationally efficient market results in the best possible utilization of available resources for the welfare of shareholders, thereby achieving a pareto optimum (2, p. 145).

Takeovers have long been recognized as an important method of achieving allocational efficiency (2, p. 180). Management which does not maximize shareholder wealth should be a target for takeover bids, thereby putting their jobs in jeopardy. In this sense, takeover activities could be viewed as a process of creative destruction, as Schumpeter argued in his book, Capitalism, Socialism and Democracy (27).
It is hard to believe that every takeover attempt is economically justified. It is also not possible that all takeover attempts could improve economic efficiency. Thus, a final decision whether to merge or not is up to shareholders. Takeover attempts succeed only when a majority of shareholders approve, because shareholders will simply choose the highest offer presented to them (16, p. 6). Since Henry Manne (25) initiated an interest in the "market for corporate control," much research has been done in an attempt to understand the motives of participants in the market, the impacts of merger announcements on the shareholders' wealth (both bidders' and targets' shareholders), the effects of takeover regulations on the profitability and probability of takeover bids, and the effects of various defensive strategies on the shareholders' wealth.

Statement of the Problem

There is considerable literature concerning the market for corporate control. However, most studies focus solely on stock market returns to the shareholders of the participating firms. Many studies estimated abnormal returns for successful and unsuccessful bidding and target firms around the announcement date of tender offers (3, 5, 10, 18) and mergers (1, 9, 11, 13, 19, 23, 24, 30) to measure the wealth effects of takeover activities. Abnormal returns are calculated by using event study methodologies.
Many studies have been done to determine the sources of gains from takeover activities. For example, Eckbo (11) and Stillman (39) tested whether gains are due to increased market power. Bradley, Desai, and Kim (4) proposed information or synergy hypotheses as two possible sources of gains. It seems impossible, however, to find exact sources of gains from takeover activities by measuring abnormal returns. Since takeovers always involve two firms simultaneously, it is hard to believe that all gains are due to a single source. As Harris et al. (14) put it: "beauty is in the eye of the beholder." Another reason is that abnormal returns alone are not sufficient evidence to identify which components of the firms' present value have changed (16, p. 24). The effect of takeover regulations on the wealth of the shareholders of the participating firms and the effects of the adoption of anti-takeover charter amendments on shareholders' wealth of the adopting firms have also been studied.

There have been few studies that examine financial characteristics of participating firms other than stock market returns. Monroe and Simkowitz (26) studied takeover target companies and concluded that targets, in general, are smaller, have lower price earning ratios, lower dividend payout ratios, and lower growth in equity. They suggest that financial characteristics may play an important role in
motivating mergers, though the exact nature of this role is unclear. Stevens (29) also studied the financial characteristics of acquired firms. His results are inconsistent with those of Monroe and Simkowitz. He finds liquidity to be important in his research, but dividend payout ratio and price earning ratio turn out to be unimportant. Harris et al. (14) used two broad variables, financial statement variables and product market characteristics, to study whether these characteristics of acquired firms differ from those of non-acquired firms. They found that product market characteristics are not important. On the other hand, size (small) and price earning ratio (low) turned out to be important variables affecting whether a firm is or is not acquired. In general, these studies (14, 26, 28, 29) do not give a consistent picture of the typical characteristics of acquired and acquiring firms, and do not give clearcut evidence favoring certain merger motives.

There are some reasons for the inconsistencies in the literature. First, the time periods covered for samples differ, and characteristics of acquired firms may change over time. Second, many research efforts deal with only either acquired firms or acquiring firms. Since takeovers are events involving two or more firms, studies which consider only one part may give erroneous impressions.
Finally, most research, implicitly or explicitly, attempts to test particular theories of merger motives. This may also bias interpretations of the results, since all changes in present value of the takeover participating firms are assumed to be attributable to a single hypothesized motive. Variable selection could be affected by hypothesized motives.

To correct the above problems, especially the second and third, a more general multicausal model with control samples would be needed. It should be of value to all concerned parties, bidders, targets, and their affected shareholders, if some light could be shed on measurable factors that distinguish acquirers from targets.

The Objectives of the Study

The main objective of this study is to examine whether the market is allocationally efficient. That is, do the acquiring firms' investment strategies increase shareholders' wealth. If resources are allocated to obtain Pareto optimal equilibrium, then the market could be called an allocationally efficient one. Testing for allocational efficiency is hard in many respects. First, it is impossible to evaluate the expected return on projects not undertaken to ascertain that all the investments whose expected rate of return equal or exceed their cost of capital are undertaken (2, p. 179). Second, allocational
efficiency cannot be achieved without informational efficiency. Consequently, any test would be a joint test of informational and allocational efficiency.

There have been many past tests of market efficiency. However, the allocational efficiency concept has been neglected under the presumption that informational efficiency could assure allocational efficiency so long as management acts in the best interests of their shareholders. This study investigates firms' external investments (obtaining control of other firms) to determine whether managements' decision to obtain control of other firms is consistent with optimal investment strategy.

Tobin's q has been known to represent a firm's investment opportunities. Some (15, 32) claim that Tobin's q theory of investment is equivalent to the neoclassical theory of investment, which includes adjustment cost. This study has two objectives: 1) to determine whether markets are allocationally efficient in terms of firms' investment behavior measured by Tobin's q, and 2) to determine whether Tobin's q could explain differences between targets and acquiring firms and could, therefore, be used to predict future takeovers.
Hypotheses

The main hypothesis of this study is that markets (in general) are allocationally efficient so that takeover activities are governed by a rule of shareholder wealth maximization. Shareholder wealth is maximized by investing in all value-increasing projects. The opportunity to invest and to increase the value of a firm can be summarized by Tobin's q (6, 15, 32). Thus, high q firms have incentive to invest, while low q firms have incentive to divest. If markets are allocationally efficient, then the values of acquirers' Tobin's q on average should be greater than those of control firms and targets' q on average should be lower than those of control firms.

Methodology

The above hypotheses will be tested by employing 1) t-test for the difference of matched sample means, and 2) probit analysis. Since two independent random samples cannot be selected, matching and adjustment for market trend procedures in the course of design and analysis of study are adopted to reduce the bias which may result from the choice-based sampling (7). Experimental firms (targets) are selected from COMPUSTAT research tape, and acquiring firms are found in the Wall Street Journal Index. Control firms are selected from the Industrial COMPUSTAT tape. The values of Tobin's q are calculated by employing a modification of the Lindenberg and Ross (21) methodology.
Limitations of the Study

Only merger events which occurred during the period of 1977 - 1983 are covered. Only COMPUSTAT listed firms are included in the study. Sample firms are selected by the choice-based sampling, not by independent random sampling.

Although marginal Tobin's q is directly related to the optimal rate of firms' investment, average Tobin's q is used to test the proposed hypotheses. Even in the calculating average Tobin's q, there are many difficulties, mainly the calculation of market value of debts and of replacement costs of various assets. These limitations will restrict the generalization of the results of this study.

Importance of the Study

It is expected that this study could provide the following contributions: 1) to test whether markets are reasonably allocationally efficient, and 2) to provide clues as to the usefulness of Tobin's q in investment decisions.

Organizational Plan

Chapter II reviews related literature. The first part of Chapter II concerns the wealth effects of takeovers, the effect of legal regulations on the probability of takeovers, shareholder wealth of participating firms, and takeover-defense strategies and resultant effect on shareholder wealth. The second part reviews Jorgenson's
theory of investment with adjustment cost, and Tobin's q theory of investment.

In Chapter III, research hypotheses are derived from the implications of Tobin's q theory of investment, and sample selection methods are described. The methodology to calculate Tobin's q is also presented. Probit and logit analysis and t-test, as possible hypotheses testing techniques, are presented with the assumptions. The effects of violating assumptions on the validity of tests and possible techniques to reduce bias are discussed also. The list of experimental and control firms selected from COMPUSTAT research and industrial files are presented in Appendix A and B respectively.
CHAPTER BIBLIOGRAPHY


CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter reviews the literature related to various aspects of takeover activities. The first part of the chapter reviews the wealth effects of takeover activities, sources of gains from takeover, the effect of takeover regulation on the probability and gains of takeovers, and target's defensive strategies and resultant effect on shareholder wealth.

The second half deals with theories of investment. Jorgenson's neoclassical theory of investment, neoclassical theory of investment with adjustment cost, and Tobin's q theory of investment are reviewed. Tobin's q theory applications in finance are reviewed as well.

Introduction to Takeovers

Takeovers are defined as activities which accompany transfer of corporate control, a valuable asset which enables its holders to manage or control corporate resources (49, p. 5). A bidder is the management team which tries to obtain corporate control from incumbent management. Incumbent managers are called target management.

Takeovers are often referred to as the market for corporate control, because several management teams compete
for the right to manage the corporate resources. This market for corporate control not only helps better allocate society's resources, but also comprises important parts of the managerial labor market discussed by Fama (29). As a result, only successful management teams retain the right to control corporate resources.

**Takeover Mechanism**

Takeovers can occur through mergers, tender offers, and/or proxy fights, or some combination thereof. A merger is defined as an agreement to combine two or more corporations under procedures established by the state of incorporation of each of the participating firms. Mergers require not only the approval of incumbent management, but the explicit approval of shareholders. Recently, many firms require more than a simple majority vote (supermajority) by shareholders to effect a merger (21, p. 329).

Mergers may be classified as horizontal, vertical or conglomerate mergers (18, pp. 560-561). If two merging firms are operating in the same line of business, a merger between the two would be horizontal. Vertical mergers involve two firms which are in different stages of production operations. When two merging firms' operations are totally different and unrelated, the merger is classified as a conglomerate merger. Mergers can be classified as friendly or unfriendly (hostile). If target
management opposes the idea of combining firms, the merger is considered unfriendly.

A tender offer is a cash or stock bid for a block of another firm's outstanding shares. Unlike mergers, tender offers are direct requests to the shareholders of a target to sell their stocks at a certain price, usually above the market price. If the fractions of shares tendered are higher than the prespecified levels, tender offers succeed and vice versa.

According to Jensen and Ruback (49, p. 7) proxy contests are usually used to settle internal power struggles. Proxy contests are often led by dissatisfied former managers or large shareholders to gain controlling seats on the Board of Directors.

**Structure of Offer**

In a tender offer, either cash, stock, or a combination of the two may be used to complete transactions between target shareholders and a bidding firm. When a bidder intends to buy part of target's outstanding shares, he makes what is called a partial tender (fractional) offer. Since only fifty per cent of outstanding shares are needed to have control over the target firm, a tender offer need not be for all the outstanding shares of the target.

Mergers use stock as the medium of exchange, and the exchange ratio is negotiated by the two management teams.
Unlike tender offers, the intent behind mergers is to buy all outstanding shares. Larson and Gonedes (63) and Conn and Neilsen (17) analyzed the theoretical determination of exchange ratio in mergers.

**Legal Regulations**

*The Williams Act.*-- This act was enacted in 1968 to regulate cash tender offers. This act provided for increased disclosure, a minimum tender period, and antifraud measures which facilitate defensive lawsuits by incumbent management (48).

There are advantages and disadvantages to this act. An advantage is the protection of target shareholders from undesirable takeovers, or raiding, by giving them more time and information for their decision. Those who oppose the act argue that the regulation only intensifies the competition for a target firm, increasing the premium paid to target shareholders (48, pp. 380-381). As a result, the bidders have less incentive to engage in takeovers; otherwise profitable takeovers may not be consummated.

*Antitrust laws.*-- These concern mergers and include the Sherman Act, the Clayton Act and the Celler-Kefauver Amendment. The Sherman Act was designed to stop the creation of monopolies via merger. The purpose of the Clayton Act was to halt and restrain monopoly power.
Section 7 of the Clayton Act prohibits mergers that would "substantially lessen competition" or "tend to create a monopoly" (91, p. 225). The Celler-Kefauver Amendment was adopted to supplement section 7 of the Clayton Act in 1959. The purpose was to significantly extend the reach of section 7 of the Clayton Act (91, p. 225).

**Defensive Strategies**

**Raising dividends.**—By raising dividends, an incumbent management could obtain shareholder support and could raise the price of its stock, making a takeover difficult. Whether the wealth of the shareholders (increased price of their stock) can be affected by dividend policy is still an unresolved issue. Theoretically, Miller and Modigliani (77) proved the irrelevance of dividend policy assuming no taxes. The same holds true even when corporate tax and growth are included in the valuation model. When personal taxes are introduced into the valuation model, Farrar and Selwyn (33) claimed that a no-dividend policy would be the optimal policy because of tax disadvantages of ordinary income over capital gains. Miller and Scholes (78) supported the irrelevance of dividend policy even with corporate and personal taxes. To explain why corporations pay dividends, the signalling hypothesis (5, 83) and agency theory (84) have been advanced.
Sometimes stock splits are purported to have similar effects of raising dividends (44). There seems to be no reason to believe that stock splits bring increased share value as long as markets are reasonably efficient (30). Like stock dividends, stock splits simply increase the number of shares outstanding without altering the stream of future cashflows of a firm.

**Repurchasing shares.**-- Repurchase of shares is a form of dividend with a more favorable tax treatment (18, p. 499). Thus, like raising dividends, it could be used to obtain shareholder support and raise stock price thereby reducing the possibility of takeover. It also has the effect of reducing the number of shares in the hands of the potential acquirer.

**Legal action.**-- The incumbent management can file a suit against the bidder for disrupting the regular operations of the target firm. This action gives incumbent management more time to find better and stronger measures with which to fight. Incumbent management may seek an injunction on the claim of misleading statements in a tender offer.

**Counter tender offer.**-- The incumbent management can bid for the stock of a third company, with payment to be made in the form of new stock. This move will diminish the
proportion of stock held by the opposition while placing
more shares in friendly hands. A counter offer can be made
to the bidder's shareholders if the firms are of similar
size. If a third company is in the same industry with the
acquiring company, then a merger between the acquirer and
the target who purchased a third company could violate
antitrust laws. This could be a justification for the
target to file a lawsuit against the bidder. In such a
case, the bidder's incentive to merge with the target will
be reduced.

    Defensive mergers.-- This strategy is sometimes the
final resort of incumbent management. If everything else
fails the management can merge the company with another
friendly company. In this case, the incumbent management
usually gets a side payment from the combined firm, such as
positions in the new firm. As long as the terms of the
merger with the "white knight" (friendly merger partner) are
no lower than other offers, shareholders of a target will
approve the merger (49, p. 47).

    Anti-takeover charter amendments.-- These are
provisions which make the conditions for the transfer of
corporate control more stringent (21). There are various
types of anti-takeover charter amendments: 1) Staggered
Board Provisions which dictate temporally staggered terms
for directors, 2) supermajority rule which requires a specific majority of shareholders (for example, 70 per cent) to approve a merger with an interested party, 3) lock-in provisions, supplemental to supermajority rule, which specify the conditions required to modify the corporate charter amendments. Usually, lock-in provisions require supermajority rule to prevent the bidder from removing previously adopted anti-takeover provisions. Another provision which might make conditions for corporate control more stringent is the Golden Parachute Clause whereby excessive and irreversible compensation schemes for the incumbent management are proposed, in case of control change.

**Standstill agreements and privately negotiated premium buyback**—A standstill agreement is a voluntary agreement (contract) which limits a particular stockholder's ownership interest in a corporation to some percentage for a specified number of years (20, p. 275). These agreements are often accompanied by the repurchase of the shares at a premium (20, p. 275). Whether or not these actions of incumbent management are in the best interest of the rest of the shareholders (other than the particular shareholder who has the above agreement) is a still unresolved issue, but they do help the target avoid the threat of being taken over.
Poison pill ploy.-- The centerpiece of this strategy is the target firm's ability to issue securities that are convertible into the common stock of whatever company it is owned by at the time of conversion. In other words, the poison pill gives shareholders of a target the right to purchase an acquiring company's stock at a bargain price, making takeover attempt too expensive. This strategy could be used to thwart a bidder who offers a high price in cash for enough stock to have control, hoping to buy the rest of the target shares at a lower price. The ploy gives target shareholders the right to convert their shares into shares of the acquiring company equal the initial tender price.

Possible Sources of Gains from Takeovers
There are many competing theories outlining the economic rationale of the transfer of corporate control. Two broad classes of merger theories have been advanced: the synergy hypothesis and the non-synergy hypothesis. When the value of the combined firms is different from the sum of the combined individual firms, synergy occurs. In the language of finance, combined cash flows are different from the sum of the two individual cash flows if synergy occurs. Synergy can occur through two different sources. Operating synergies result from reductions in production or administrative costs. Adoption of efficient production or management technology, or economies of scale could result in
operating synergy. Financial synergies can be achieved by reducing bankruptcy cost, using favorable tax considerations, or increasing leverage (49, pp. 23-24). While operating synergy increases cash flow for the combined firm, financial synergy results in the reduction of cost of capital, resulting in a higher value for the combined firm than the sum of the values of the individual firms (34, 35).

Muller (81) hypothesized that managerialism, or empire-building motive, motivates managers to increase the size of the firm. This theory claims that managers are not optimizing shareholders' wealth; rather, they optimize their own wealth. It is assumed that managers' compensation is largely a function of firm size. The information hypothesis assumes asymmetric information (11). According to this theory, a takeover results when someone takes advantage of inside information that target shares are underpriced. An increased market power hypothesis (26, 28, 91) and an inefficient management removal hypothesis (18, p. 563) have also been proposed.

The Wealth Effects of Takeovers

Much research has been done to estimate the wealth effects of takeovers for bidding and target firms. Most use the cumulative average residual (CAR) technique to measure the wealth changes for shareholders. Early studies (28, 62, 73) used the effective date of merger as the event date
instead of the announcement date. Since the announcement
date occurs prior to the effective date, it is difficult to
get accurate estimates of stock price changes using the
effective date as an event date, since estimated pre-merger
gains could result from the market reaction to the earlier
release of this information. Empirical evidence shows (25, p. 352) that more than two-thirds of successful tender
offers are followed by formal mergers within five years;
therefore, the early merger studies are likely to produce
biased results. This type of research asks the questions of
whether takeovers create gains and, if there is gain, how is
this gain divided between buyers and sellers.

Research (4, 23, 26) indicates that acquired firm
shareholders achieve significant gains from the period just
before the merger announcement date. For the acquiring
firm, shareholders neither gain nor lose significantly for
the period just before the merger announcement date. For
tender offers (10, 11, 25, 61), both bidders and targets
gain. Most research reaches similar conclusions, although
methodologies and samples differ. This section briefly
reviews research on this topic. For convenience, merger and
tender offer studies are reviewed separately.
Merger Studies

Lev and Mandelker (1972)

Lev and Mandelker (65) used a paired comparison design to test whether acquiring firms gain from merger. For each of sixty-nine acquired and matching firms, they calculated ten annual rates of return on the stock market, five years before and five years after merger. Next, they calculated the difference between the post-merger and pre-merger five year average rate of return. By subtracting the difference of a matching firm from that of an acquiring firm, they calculated residuals for each of sample pairs. The acquiring firms' profitability was, on an average, 5.6 percent more than that of matching firms. Explicit consideration of risk factors was not included in the study.

Mandelker (1974)

Mandelker (73) used an asset pricing model to test two hypotheses: 1) acquisitions take place in a perfectly competitive market, and 2) merger markets are informationally efficient. To calculate the abnormal rates of return, the methodology developed and applied by Black, Jensen, and Scholes (8) and Fama and MacBeth (31) was employed.

Acquired firms' cumulative average residuals were positive, indicating gains from mergers. Competition in the market for acquisitions results in competitively high prices.
for acquired firms and only normal rate of return to the acquiring firms. The stock market operates efficiently with respect to merger information. Stockholders are not misled by merger accounting manipulations or by artificial increases in earnings per share. Though significant changes in beta were observed, rates of return adjusted to changes in risk were claimed to indicate that capital markets are informationally efficient with respect to information on mergers.

**Langetieg (1978)**

Langetieg (1978) measured the magnitude of gains from mergers by employing four different two-factor models as well as a matched non-merging control firm sample. The first factor is a market factor. The second factor employed is an industry factor. Four different performance indexes are based on either the standard capital asset pricing model or Black's (7) version of the Capital Asset Pricing Model with two alternative industry factors.

Langtieg's results for the four models were generally consistent with those of Mandelker. However, the inclusion of the industry factor and the control group was found to be very important for performance measurement.

Langetieg concluded that post-merger excess return experience is consistent with the efficient market hypothesis. Both acquirers and targets benefit from
mergers, but the target shareholders' gain is substantially higher than that of the acquirers.

Dodd (1980)

Dodd (23) employed a market model to measure the stockholders gain for both successful and unsuccessful mergers. Daily returns were calculated for 151 merger proposals during the period from 1971 to 1977. Seventy-one of these were completed. The others were cancelled by either target or bidder management. The reason for using daily returns was to indicate the importance of the announcement date; there may be an information leakage even before public announcements. Target firms earn positive abnormal returns from the announcement of a merger proposal. The CAR for completed mergers from day -10 (before proposal) to day 10 (after approval) was 33.96 percent. For cancelled cases, the total sample (eighty proposals) CAR was 3.68 percent, target initiated cancellations' CAR was 10.95 percent and bidder initiated cancellations' CAR was 0.18 percent over the same period from day -10 (before proposal) to day 10 (after proposal).

On the other hand, bidder firms (both completed and cancelled mergers) earn negative abnormal returns (-7.22 percent and -5.50 percent respectively), leading to the conclusion that all the gains from mergers go to target firms.
Malatesta (1982)

Malatesta (72) calculated percentage returns as well as the abnormal dollar return to examine the wealth effects of mergers. The three hypotheses considered in this study were the value-maximizing hypothesis, the size-maximizing hypothesis, and the improved management hypothesis. Malatesta used two definitions for event dates. The first, \( t_1 \), is the "time when investors learn that a future merger is possible" (72, p. 158), and the second, \( t_2 \), is a date when "investors learn that the merger will actually take place or that the attempt has been abandoned" (72, p. 158). The announcement date is taken as a proxy for \( t_1 \). For \( t_2 \), Malatesta's proxy is management approval of the merger. A market model was used as a return-generating process.

Malatesta found that the wealth of the acquired firms' shareholders increased around merger announcement dates. However, large negative returns accrue to acquired firms over periods well before the public announcement date. Average accumulative abnormal dollar return over the period sixty months before to the approval date is -9.42 million dollars. Malatesta claimed that "only the improved-management hypothesis correctly predicts the pattern of acquired-firm results." Malatesta also found that, for acquiring firms, the average abnormal dollar return is significantly negative for both the periods of
return is significantly negative for both the periods of four months before to the approval date, and five years leading up to the approval date. Thus, Malatesta concludes that acquiring firms' return behavior is consistent with the size-maximizing behavior.

Tender Offer Studies

Kummer and Hoffmeister (1978)

Kummer and Hoffmeister (61) examined the stock returns of target firms prior to announcement of a tender offer, evaluated tender offers according to their success or failure and their resistance or non-resistance by incumbent management of the target firm, and investigated the return to bidding firms prior and subsequent to tender offers.

The sample included eighty-eight cash tender offers occurring during the period from 1956 to 1974. It included forty-four passive-successful offers, fifteen resisted-unsuccessful targets in which no subsequent offers were announced within ten months of the offer, and six resisted-successful targets.

All target firms had negative, statistically significant CARs except for the passive-successful targets for the period from forty months before to four months before announcement. The negative CARs ranged from 10 to 20 percent. However, average residuals ranging from 16 to 20 percent were observed for three different types of sample
offers for the month of announcement. Resisted unsuccessful
tender offers showed that the CARs do not return to their
pre-announcement level even after the market perceives
resistance and failure of the offer. Kummer and Hoffmeister
attributed this to "the likelihood of an eventual takeover
by a friendly firm or of a change in policy by the target
firms" (61, p. 511). Observed premiums for the resisted
offers are significantly higher than those for the passive
tender offers.

They concluded that takeovers lead to increased
shareholder wealth for both target and bidder and these
gains come from the efficient utilization of corporate
resources by replacing incumbent managements.

Dodd and Ruback (1977)

This study (25) examined the impacts of the tender
offers on the returns to stockholders of both targets and
bidders. Both successful and unsuccessful tender offers
were included in the sample of 172 bidders (124 successful)
and 172 targets (136 successful). The market model was
employed to measure the stock market reactions to the
announcement of tender offers.

A dummy variable regression was run for each firm to
test whether there was a change in risk (beta) after the
tender offer. One hundred twenty months of data were used:
sixty months before and sixty months after the offer,
excluding the thirteen months either side of the event. Only thirty-four out of 184 firms exhibited significant change in beta at the 5 percent level.

In the month of announcement, successful targets had a positive 20.58 percent abnormal return, 18.96 percent for the unsuccessful targets. For the acquirers, the average residuals for both successful and unsuccessful bidders fluctuate randomly around zero. Successful bidders earn 2.83 percent and unsuccessful bidders earn only 0.5 percent. After the offer the CARs display no distinct pattern for all classes of firms. While both successful and unsuccessful target firms appear to earn normal rates of return for the period from sixty months before to one month before public announcement, bidders earn 11.69 percent when successful and 5.93 percent when unsuccessful for the same period.

They concluded that the pattern of cumulative average residual shown is consistent with the internal efficiency hypothesis, not with the monopoly power or synergy hypotheses.

Bradley (1980)

Bradley (10) studied 258 cash tender offers that took place during July 1962 and December 1977 to examine the sources of gains from tender offers. To test the price behavior of the shares of firms involved in tender offers, the following steps were used. First, Bradley divided the
tender offer process into three discrete time periods: pre-announcement period, post-announcement but pre-execution period, and post-execution period. Second, Bradley calculated a time series of several price indexes for each firm: equity price index, abnormal equity price index, offer price index per target share purchased and offer price index per target share outstanding. Third, mean price indexes of the shares of sample firms (successful target, successful bidder, unsuccessful target and unsuccessful bidder) were calculated and compared to the predicted series derived from theory.

Bradley's theory implied that for successful offers, the shareholders of both firms will experience a capital gain. The gains to the target firms will be realized through the premium or post-execution revaluation depending upon whether shares are tendered or not. The gains to bidders will come from the offer, but not from the subsequent appreciation of the target shares. For unsuccessful offers, the post-expiration market price of the target shares will be greater than the value of the rejected bid.

For the 161 successful tender offers the mean premium was 49 percent. The post-execution price of target share was 36 percent higher than its pre-announcement level. Hence, there is a 13 percent loss per target share to the acquirer. Bradley claimed that despite the high premium
paid, the shareholders of acquirers realize an excess capital gain of 5 percent within five trading days of the offer. Therefore, tender offers bring about synergetic gains. In case of unsuccessful offers (thirty-three firms), the post-execution market price of a target share is 67 percent above the pre-announcement level. This increase is even higher than that of successful offers. The results hold for only tender offers for which all shares were bid. For fractional offers the target shareholders realized a 36 percent gain relative to the pre-announcement price. Bradley concluded that the above findings are consistent with a synergy interpretation of interfirm tender offers.

The Effects of Legal Regulations

**Ellert (1976)**

Ellert (28) analyzed 205 defendants in anti-merger complaints initiated by the Justice Department and Federal Trade Commission under section seven of the Clayton Act for the period of 1950 - 1972. Sixty percent (123 firms) of the total sample cancelled merger plans or were ordered to divest part or all of the assets previously acquired. For a four year period preceding the filing of a complaint the residuals were positive for both groups (divested or not). The CAR was over 18 percent for the group which was ordered to divest; 13 percent for the other group. For the four years prior to the filing of the complaints, the first group
(required to divest) had further positive residuals which are statistically significant. The second group had returns that were not significantly different from the average market.

The behavior of residuals following the filing of merger complaints is not statistically significant. The behavior patterns of returns both after the settlement of the litigation and for the period between the filing of the complaint and the settlement of the litigation are not statistically different from the market as a whole. Based on this evidence, Ellert concluded that the actions taken by the antitrust authorities cannot bring about significant positive outcomes and, thus, rejected the monopoly hypothesis of merger motives.

Eckbo (1983)

Eckbo (26) hypothesized that horizontal mergers generate positive abnormal returns to shareholders of bidders and targets, because they increase the probability of successful collusion among rival producers. The basic proposition is that the rivals can expect to benefit from the news of a horizontal merger which significantly reduces the cost of enforcing a tacit collusive agreement within the industry of merging firms. This proposition is tested by estimating daily abnormal returns of a sample of horizontal mergers in mining and manufacturing industries, including
mergers challenged by the government with violating antitrust laws, and a control sample of vertical mergers occurring in the same industries.

Eckbo found that the rivals of the sixty-five horizontal challenged mergers on average earn significantly positive abnormal returns at the time of the merger proposal announcement (2.45 percent for the period from twenty days before to ten days after announcement). The rivals on average show 1.78 percent abnormal performance over the thirty-one days surrounding the date of subsequent news about the antitrust complaint, though the subsequent news of the antitrust complaints cause reduction in the market value of the merging firms. These results show that there is little evidence indicating that the mergers would have had collusive, anti-competitive effects. However, the results are consistent with the productive efficiency hypothesis, which attributes the positive performance shown by the rivals of the challenged mergers to the future cost-savings made possible by information signalled through the merger proposal announcement.

Eckbo also found that the performance of rivals of horizontal unchallenged mergers is indistinguishable from the performance of rivals of vertical unchallenged mergers in the same industry. Eckbo rejected the collusion hypothesis as a reason for mergers.
Jarrell and Bradley (1980) studied the effects of tender offer regulations, the Williams Act, and many federal and state regulations on the premiums paid to target shares and on the volume and the probability of takeover activities. The intent of the Williams Act is to protect target shareholders by providing them with more information about the acquirer and future plans for the target after gaining control and by giving them more time to decide whether to tender or not. Supporters of regulating tender offer activities argue that the costs of regulations (such as administrative costs of preparing the required disclosure documents) are smaller than the benefits to target shareholders of having an orderly, well-informed market for corporate control. Another view opposes regulations in that they only increase the information leakage resulting in keener competition for the target firm, thereby increasing premiums paid to gain control of a target. The result would be reduced incentive to engage in takeover activities.

One hundred and sixty-one targets were included in the data. Forty-seven offers occurred in the pre-regulated period (before 1968), ninety-four offers were subject to only federal regulation, and the rest, twenty offers, were subject to both state and federal regulations. Daily returns were calculated over the period from forty days prior to the announcement to eighty days following.
The mean premium paid was increased from 32.4 percent (no regulation period) to 52.8 percent (federal regulation only) to 73.1 percent (both federal and state regulations). The percentage of target shares purchased also increased—from 42.1 percent to 71.8 percent. Jarrell and Bradley concluded that regulations raise the purchase price of target shares, reduce the volume and the probability of takeovers and decrease the returns to the bidders.

Effects of Defensive Strategies on Stockholders

DeAngelo and Rice (1983)

DeAngelo and Rice (21) examined the effect of the adoption of anti-takeover charter amendments on stock prices of adopting firms. The purported intent of anti-takeover charter amendments is to impede the ability of an outsider to gain control of the firm. Two hypotheses were advanced: stockholder interest hypothesis and managerial entrenchment hypothesis. While the latter views adoption of anti-takeover charter amendments as a wealth-decreasing transaction, the former supports adoption of them as a wealth-increasing transaction.

DeAngelo and Rice examined 100 firms who adopted anti-takeover charter amendments like supermajority rule, staggered board provisions, fair price and lock-up provisions, during the period from 1974 to 1978. Stockholders of these firms realized an abnormal return of
-0.16 percent (statistically insignificant) on the day after the mailing date of the proxy containing the proposals. Over the period from ten days before to eleven days after mailing date, the cumulative average residual was an insignificant -0.9 percent. Their conclusion was that these provisions do not reduce shareholder wealth significantly.

Linn and McConnell (1983)

Unlike the previous research by DeAngelo and Rice (21), Linn and McConnell (67) examined abnormal stock returns throughout the amendment process. The reason was due to the difficulty of identifying an exact event date since information about anti-takeover provisions may be released on the date the board approves the provisions or on the date of stockholder approval. These two event dates, in addition to the proxy mailing date, were used in this study. Three hundred and eighty-eight firms which adopted anti-takeover charter amendments during the period between 1960 and 1980 were included in the sample, to investigate the impact of anti-takeover charter amendments on firms' common stock prices.

For 170 firms in which the day of board approval is available, the market-model CAR for the period from board approval to the proxy mailing date was an insignificant 0.71 percent. The CAR over the period from proxy mailing date to stockholder meeting day was 1.43 percent which is
statistically significant (for 307 firms). For the period from stockholder meeting day to ninety days later, the CAR was an insignificant 0.86 percent.

Linn and McConnell concluded that anti-takeover charter amendments do not decrease stockholder wealth. Weak support was found for the contention that adoption of anti-takeover provisions increase shareholders' wealth.

Dodd and Leftwich (1980)

Dodd and Leftwich (24) investigated changes in stockholder returns associated with changes in the state of incorporation during the period of 1927 to 1977. One hundred and twenty-six out of 140 sample cases reincorporated in Delaware (a state with very lenient codes on corporate charter rules). By changing the state of incorporation, the probability of a firm's being a target can be affected. For example, if a firm changes its state of incorporation to Delaware and adopts stringent anti-takeover charter amendments, then this firm will not be as attractive to possible acquirers. Two hypotheses were proposed by Dodd and Leftwich to explain the reincorporation in Delaware. First, managers may take advantage of minimal restrictions on charter rules in Delaware to exploit shareholders. Or, second, managers may take actions to increase shareholder wealth that are impossible in more restrictive states.
Abnormal return was about 30 percent during the period from twenty-four months before the month of announcement. This large a return cannot be attributable solely to the changes in the state of incorporation. Dodd and Leftwich concluded that firms changed their state of incorporation after a period of superior performance and that the change itself is associated with small positive abnormal returns.

**Dann and DeAngelo (1983)**

Dann and DeAngelo (20) examined the effects of standstill agreements and premium buybacks on stock prices of those firms who agree to provide either of the above contracts. Standstill agreements are voluntary contracts between a corporation and a substantial shareholder which limits the stockholder's ownership to some maximum percentage for a specified period. This agreement is often accompanied by a repurchase of the shareholder's stock at a premium. These strategies are intended to reduce competition for control of the firm, thereby decreasing the threat of being a takeover target. As in DeAngelo and Rice (21), the two hypotheses proposed were the stockholder interest hypothesis and the managerial entrenchment hypothesis.

Price impacts were measured with the market model. Market reaction to the first public announcement of standstill agreements (thirty agreements--whole sample) was
-4.52 percent for the two days from one day before to the announcement day. Negative returns were also observed for the nineteen firms who offered only standstill agreements (i.e., not accompanied by repurchase). The announcement of premium buyback (forty-one firms--whole sample) also showed negative returns of -1.76 percent for the same two day period. Premium buybacks, not accompanied by standstill agreements, also had a negative return of -1.16 percent. Dann and DeAngelo concluded that the above evidence is inconsistent with the stockholder interest hypothesis.

Introduction to The Theory of Investments

Haavelmo (40), Lerner (64), and Witte (99) argued that there is no investment demand schedule for an individual firm. The reason for their conclusion is that under the assumptions of constant prices, competitive market and small enough firms, firms can adjust instantaneously to the desired stock of capital which is constant. Therefore, investment is always equal to the amount of depreciation, and there is no investment function as such. In other words, capital is adjusted to the desired level instantaneously at the initial time, and it will be kept constant over the whole planning horizon (40, p. 163).

On the other hand, Jorgenson (54, p. 226) contended that "it is possible to derive a demand function based on purely neoclassical considerations." What he did to obtain
the investment demand schedule was to change price for investment goods over time. Thus, investment changes over time depending on the time path of price. Tobin (93, p. 157) argued that the basic tenets of the Lerner-Haavelmo argument, the instantaneous adjustment to the desired capital stock, was not changed even in Jorgenson's model. That is, Jorgenson's model would also give constant investment over time if constant prices are assumed.

The earlier version of the neoclassical approach developed by Jorgenson derives the optimal capital stock under constant return to scale and exogenously given output. To obtain an investment schedule, Jorgenson and associates employed a distributed lag function for net investment. This approach was criticized for its inability to determine the rate of investment; rather, it relied on an ad hoc stock adjustment mechanism (43, p. 213). Employing a distributed lag function for investment implicitly assumes that some sort of adjustment costs are needed to change capital stock. This leads to the explicit inclusion of adjustment cost in the neoclassical theory of investment.

After Jorgenson, many theorists (38, 70, 96, 97) tried to develop a better investment theory for firms. Adjustment costs were explicitly included in the firm's optimization problem. Inclusion of a convex adjustment cost function allows optimal investment to be uniquely determined and
constant over time as the capital stock monotonically approaches the long-run desired level (as time approaches infinity).

An alternative theory is the q theory suggested by Tobin (94, 95). He claimed that the rate of investment is a function of q, the ratio of the market value of the new additional investment goods to their replacement cost. Yoshikawa (100) and Hayashi (43) have shown that the neoclassical theory of investment with adjustment cost is equivalent to Tobin's q theory.

Earlier Version of the Neoclassical Theory of Investment

Jorgenson, rejecting Haavelmo, Lerner, and Witte's ideas, developed an earlier version of the neoclassical investment theory. Neoclassical theory of investment starts with the optimal capital accumulation problem which maximizes the present value of the firm. This section will draw on the article by Jorgenson (54).

Let $R(t)$ be the flow of net receipts at time $t$, then

$$R(t) = P(t)Q(t) - w(t)L(t) - u(t)I(t) \quad (2-1)$$

where $Q, L, \text{ and } I$ represent levels of output, variable input, and investment in durable goods and $p, w, \text{ and } u$ represent the corresponding prices. The present value of the firm is defined as the integral of discounted net receipts; the present value of the firm ($W$) will be given by:
\[ W = \int_0^\infty \exp[-r(s)ds] R(t)dt \quad (2-2) \]

Where \( r(s) \) is the rate of discount at time \( s \).

Jorgenson simplified the above equation by assuming a constant time discount rate, \( r(s) = r \), for all \( s \). As a result, the present value of the firm, \( W \), will be simplified:

\[ W = \int_0^\infty \exp[-rt] R(t)dt \quad (2-3) \]

This objective function is maximized under two constraints. First, the firm’s production function is \( F(Q, L, K) = 0 \) and \( \dot{K}(t) = I(t) - \delta K(t) \), where \( \dot{K} \) is the time rate of change of the flow of capital services. A dot over a variable denotes its time derivative. \( \delta \) is the constant rate of depreciation.

The production function \( F \) is assumed to be twice differentiable with positive marginal rate of substitution between inputs and positive marginal productivities of both inputs, and \( F \) is also assumed to be strictly convex. The second constraint means net investment is equal to total investment less replacement. The neoclassical capital accumulation problem is summarized as follows:

\[ \text{Maximize} \quad W = \int_0^\infty \exp(-rt)R(t)dt \quad (2-3) \]

\[ \text{Subject to} \quad \dot{K}(t) = I(t) - \delta K(t) \quad (2-4) \]

and \( F(Q, K, L) = 0 \quad (2-5) \)
To solve the above problem Jorgenson used the classical calculus of variations approach. The Lagrangian expression would be:

\[ l = \int_0^\infty [\exp(-rt)R(t) + \lambda_0(t)F(Q, K, L) + \lambda_i(t)(K - I + \delta K)] \, dt \]  \hspace{1cm} (2-6)

where \( f(t) = \exp(-rt)R(t) + \lambda_0(t)F(Q, K, L) + \lambda_i(t)(K - I + \delta K) \).

The Euler necessary conditions for a maximum of present value subject to two constraints are (54, pp. 218-219):

\[ f_Q = p[\exp(-rt)] + \lambda_0(t)F_Q = 0 \]  \hspace{1cm} (2-7)

\[ f_L = w[\exp(-rt)] + \lambda_0(t)F_L = 0 \]  \hspace{1cm} (2-8)

\[ f_I = u[\exp(-rt)] - \lambda_0(t) = 0 \]  \hspace{1cm} (2-9)

\[ f_k \frac{dt}{dt} \frac{df}{dK} = \lambda_0(t)F_k + \delta \lambda_i(t) - \frac{dt}{dt} \lambda_i(t) = 0 \]  \hspace{1cm} (2-10)

\[ f_{\lambda_0} = F(Q, K, L) = 0 \]  \hspace{1cm} (2-11)

\[ f_{\lambda_i} = k - I + \delta K = 0 \]  \hspace{1cm} (2-12)

Equations (11) and (12) are constraints imposed at the outset. Combining equations (7) and (8), we obtain:

\[ Q_L = \frac{w}{p} \]  \hspace{1cm} (2-13)
the marginal productivity condition for labor services. A similar marginal productivity condition for capital services can be derived. From equation (2-9),

\[ \lambda(t) = u[-\exp(-rt)]. \]  

(2-14)

By substituting equation (2-14) into equation (2-10),

\[ 0 = \lambda(t)F_k - \delta u \exp(-rt) - ru \exp(-rt) + \dot{u}\exp(-rt) \]  

(2-15)

Combining this with equation (2-7),

\[ \frac{\partial Q}{\partial K} = \frac{u(r + \delta) - \dot{u}}{p} = \frac{c}{p}, \]  

(2-16)

where, \( c = u(r+\delta)-\dot{u} \). \( c \) is the implicit rental value of capital services supplied by the firm to itself.

Therefore, the complete neoclassical model of optimal capital accumulation consists of the following:

\[ I = \dot{K} + \delta K \]  

(2-4)

\[ F(Q, K, L) = 0 \]  

(2-5)

\[ Q_L = w/p \]  

(2-13)

\[ Q_k = c/p \]  

(2-16)

\[ c = u(r + \delta) - \dot{u} \]  

(2-17)
From the above neoclassical optimal capital accumulation model, an optimal capital stock, $K^*$, can be obtained. If adjustment is cost-free and frictionless and the volume of investment is unbounded, then the firm can adjust very quickly to its long-run desired stock of capital, $K^*$.

Jorgenson and Siebert (55, p. 688), then insisted that the actual stock, $K(t)$, is, in general, different from the desired level $K^*(t)$. In reality, a firm cannot adjust its stock of capital to the desired level instantaneously and frictionlessly. This notion led them to devise a way to accommodate this adjustment. One way of adjusting it is to use a geometrically declining distributed lag mechanism (55); that is, actual capital is a weighted average of all past levels of desired stock of capital with geometrically declining weight. Although Jorgenson and Siebert (55, 56, 57) demonstrated statistical support, there is a flaw in this theory of investment. The inclusion of a response mechanism for empirical purposes is a contradiction to their theory. It implies that the adjustment to the desired stock is neither instantaneous nor frictionless. If adjustments are not frictionless and involve lag, then it should be incorporated into the maximization behavior of the firms. This criticism led to the explicit inclusion of adjustment costs in the maximization problem.
Neoclassical Theory of Investment with Adjustment Costs

This version of the neoclassical theory of investment explicitly includes adjustment cost in the firm's optimization problem. It provides a possible remedy to the problem of Jorgensonian approach, which relies on an ad hoc stock adjustment mechanism. In this formulation, what the firm can control at each moment in time is its rate of investment, although the stock of capital is fixed. The problem now is to incorporate adjustment costs into the firm's optimization problem.

Adjustment Costs

Adjustment costs can be introduced in several ways. One way to deal with this problem is to hypothesize that the average economic price of capital goods, \( u \), increases as the rate of investment increases. Eisner and Strotz (27), Lucas (68), and Gould (38) suggested the following model to replace \( u(t)I(t) \) in equation (2-1):

\[
C(t)=C(I(t)) \tag{2-18}
\]

where \( C \) is an adjustment cost function, as a function of investment. \( C \) is assumed to have the following properties:

\( C(t)>0, \quad C'>0, \quad C''>0 \quad \text{for all} \quad I(t)>0 \)

\( C'(0)>0, \quad C(0)=0. \tag{2-19} \)
C' and C'' are the first and second derivative with respect to investment, respectively. The condition C'' > 0 means the adjustment cost function is convex. This kind of adjustment cost behavior arises from the scarcity of capital. In other words, the cost of gross investment (per unit) rises with the investment rate, because capital is reasonably fixed in the short run. Takayama (92, pp. 697-698) summarizes this point by saying that

this cost behavior can be rationalized, for example, (1) by postulating a monopsonistic capital goods market, or (2) by introducing internal cost of investment which are sum of the purchase cost (with either perfect or imperfect factor markets) and installation costs.

Lucas (69) devised another approach by altering the usual production function equation (2-5), into the following form:

\[ F( Q(t), L(t), K(t), I(t)) = 0 \]  

(2-20)

F is assumed to have negative first and second partial derivatives with respect to investment for all positive levels of Q, L, K, I. This formulation implies that the rate of output will diminish as investment increases. This kind of cost behavior occurs when adjustment costs are viewed as the internal costs of the foregone output. Treadway (96) used the same approach in his study. Yet another alternative, to introduce adjustment costs associated with the investment, was developed by Uzawa (97).
A remaining question is the correct specification of the adjustment cost function. As noted in Takayama (92, p. 698), the choice of an adjustment cost function may alter the conclusion. He also argued that "such a choice would depend on empirical considerations and may vary between industries" (92, p. 698).

A crucial weakness in the formulation of adjustment cost is the lack of a lag between investment decisions and actual investment. Even though theory has addressed one investment lag, there are other lags that are yet to be included (92, pp. 705-706).

**Gould**

Gould (38) extended the Jorgensonian approach by introducing an adjustment cost function in an optimization problem, and studied investment paths of firms under the assumptions of constant prices and varying prices. The quadratic form of adjustment cost function is used:

$$C(I) = a_0 I + a_1 I^2$$  \hspace{1cm} (2-21)

where $a_0$ and $a_1$ are coefficients which affect the degree of adjustment cost. This type of cost function assumes that there are diseconomies of scale associated with more rapid changes in capital stock. Gould also adopted the assumptions of: 1) constant percentage depreciation (i.e., $D(K) = \delta K$), and 2) a production function that is homogenous of degree one.
Using the above assumptions, Gould derived a general solution which maximizes the following present value of the firm:

\[ W = \int_0^\infty \exp(-r(t)) [p(t)Q - w(t)L(t) - C(I)] \, dt \]  \hspace{1cm} (2-22)

where \( r(t) = \int_0^t r(e) \, de \), \( r(e) \) is the instantaneous interest rate prevailing at time \( e \), \( p(t) \) is the price of output as a function of time, \( w(t) \) is the wage rate, \( Q \) is output, and \( L(t) \) is labor input. \( C(I) \) represents the adjustment cost. Output, \( Q \), is determined by the production function \( F(K,L) \).

The capital accumulation equation is \( I = K + D(K) \). Unlike Jorgenson, Gould adopted Pontryagin's Maximum Principle (47) to solve the optimization problem. Classical calculus of variation and maximum principle approaches are two famous techniques to solve a dynamic economizing problem, together with the dynamic programming approach (6, 47).

The solution derived from maximizing \( W \) is (38, p. 51):

\[ I(t) = \int_t^\infty f(s) \exp\left( -\int_s^t (r(e) + \delta) \, de \right) \, ds \] \hspace{1cm} (2-23)

where \( f(t) = [p(t)G(w/p) - a_0(r(t) + \delta)]/2a_1 \). If constant prices are assumed, equation (2-23) becomes (38, p. 51):

\[ I(t) = \frac{pG(w/p) - a_0(r+\delta)}{2a_1} \int_t^\infty \exp\left( (r+\delta)(t-s) \right) \, ds \] \hspace{1cm} (2-24)

or

\[ I^* = \frac{[pG(w/p) - a_0(r+\delta)]}{2a_1(r+\delta)} \] \hspace{1cm} (2-25)
which is constant. Gould also showed that $I^* = \delta K^*$, which implies that the optimum rate of investment will be the amount needed to just maintain the long run desired capital stock indefinitely. Since $I = \dot{K} + \delta K$, it implies

$$\dot{K} = \delta (K^* - K).$$  \hspace{1cm} (2-26)

This finding is gratifying since it shows, for the case of constant prices, that the recognition of adjustment costs in the objective function leads to a well-defined investment function. If the assumptions of constant prices, wages, and interest rate are relaxed, the general solution, equation (2-23), does not lead to a simple adjustment scheme such as equation (2-26). In such case the investment is no longer myopic; that is, a solution for a static optimization is not equal to the one for the dynamic optimization problem. Gould concludes (38, p. 54) that "when time dependent prices are introduced, the investment path is no longer a geometrically declining distributed lag and there is little evidence to indicate that an auxiliary adjustment mechanism of any fixed form will work for all firms and at all times."

Treadway

In the literature concerning adjustment costs, it is generally assumed that the production function is homogeneous of degree one. Treadway (96) considers the
nonconstant return to scale case. The optimization problem that a firm is postulated to solve is as follows (96, p. 230):

\[
\max W = \int_0^\infty (pQ - wL - uI)\exp(-rt)dt = \int_0^\infty R(t)\exp(-rt)dt
\]

subject to \( Q = F(K,L) - C(K) \) \hspace{1cm} (2-27)
\[ K = I - \delta K, \quad K(0) = K_0 \]
\[ K, \quad L > 0 \]

Where \( W \) is the present value of the firm. Net cash flow of the firm, \( R(t) \), is its revenue \( (PQ) \) less rental payments for input \( (WL) \) and payment for total investment \( (uI) \). \( Q \) is output determined by the production function \( F \) and an adjustment cost function \( C(I) \). In this formulation, two additional constraints are augmented: 1) The initial condition for the capital stock, \( K(0) \), is equal to \( K_0 \), and 2) positive amounts of capital and inputs for the whole planning horizon.

To solve the above problem, Treadway used the Maximum Principle and formed Hamiltonian expression like the following (96, p. 230):

\[
H(K; I, L; \lambda) = \exp(-rt)[pF(K,L) - pC(I - \delta K) - wL - uI + \lambda(I - \delta K)] \hspace{1cm} (2-28)
\]
Where $H$ denotes a Hamiltonian function. $K$ is a state variable, $I$ and $L$ are control variables and $\lambda$ is a shadow price of $K$. The shadow price, $\lambda$, can be interpreted as the marginal contributions of the state variable, $K$, to the objective function being maximized.

The necessary conditions for the problem (2-27) are (96, p. 230):

\begin{align*}
K &= I - \delta K, \quad K(0) = K_0 \quad (2-29) \\
\dot{\lambda} &= (r + \delta)\lambda - \delta pC'(I - \delta K) - pF_k(K,L) \quad (2-30) \\
w &= pF_L(K,L) \quad (2-31) \\
\dot{\lambda} &= u + pC'(I - \delta K) \quad (2-32) \\
\lim_{t \to \infty} \exp(-rt) &= 0 \quad (2-33) \\
-pC''(I - \delta K)\exp(-rt) &< 0 \quad (2-34)
\end{align*}

Equation (2-29) is just a feasibility condition. Condition (2-31) implies marginal product of labor should be equal to the real wage. Equation (2-30) can be reduced to equation (2-35), an integral form, by solving the differential equation (2-30) and using the relationship that $F_k(K,L) + \delta C'(K) = \frac{\partial Q}{\partial K} = \partial Q/\partial K$.

\[ \lambda(t) = \int_0^{\infty} p \frac{\partial Q}{\partial K} K \exp\left[-(r + \delta)(t - \tau)\right] \, d\tau. \quad (2-35) \]

The value $\lambda(t)$ is the discounted value of later marginal product of capital at time $t$. Equation (2-32) requires that $\lambda(t)$ in equation (2-35) be equal to the marginal cost of
expansion at time \( t \). The cost of expansion has two parts: \( u \), the market cost per unit, and \( pC'(K) \), the internal cost in the form of foregone output. Equation (2-33) requires that the present value of investment projected for time \( t \) be approximately equal to zero as \( t \) goes into the arbitrarily distant future. Equation (2-34) is a second order condition necessary for maximal present value.

By differentiating equation (2-32) with respect to \( t \) and successive substitutions into equation (2-30), the following optimum conditions can be obtained (96, p. 231):

\[
\dot{K} = [(r + \delta)g - F_k(K, L) + rC'(K)]/C''(K) \tag{2-36}
\]

\[
F_L(K, L) = w/P = \omega \tag{2-37}
\]

\[
\lim_{t \to \infty} C'(K) \exp(-rt) = 0 \tag{2-38}
\]

where \( \omega = w/P \) and \( g = u/P \). If the production function \( F \) is homogeneous of degree one, then marginal products depend only on the capital labor ratio, \( k = K/L \). Equation (2-37) determines this ratio \( k^* = k^*(\omega) \) and this value \( k^* \) exists uniquely for any positive real wage rate \( \omega \). Under the assumption of constant return to scale, equation (2-36) becomes (96, p. 232):
\[
\dot{K} = [(r + \delta)g - F_k(k^*(\omega), 1) + rC'(\dot{K})]/C''(\dot{K})
\]  
(2-39)

Thus, a single net expansion rate \( k^* \) will be given under \( \dot{K} = 0 \):

\[
C'(k^*) = [F_k(k^*(\omega), 1) - (r + \delta)g]/r.
\]  
(2-40)

The level \( \dot{k}^* \) is uniquely determined when \( C'' \) exhibits a positive sign. Equation (2-39) also indicates that \( \dot{K} > 0 \) as \( \dot{K} > k^* \). This implies that there exists one path characterized by a constant expansion rate \( k^* \) which uniquely satisfies equation (2-38). Investment demand would be a function of real wage \( \omega \), real cost of investment per unit \( g \) and market interest rate \( r \).

\[
\dot{k}^* = \dot{k}^* (\omega, g, r)
\]  
(2-41)

In the case of variable return-to-scale, Treadway derived the following investment demand function (96, p. 237):

\[
\dot{k}^* = \dot{k}^* (\omega, g, r, K)
\]  
(2-42)

Equation (2-42) implies that \( k^* \) is affected by capital stock \( K \). Treadway shows that the assumption of constant return to scale is crucial in obtaining the conclusion in which constant investment over time is optimal.
Tobin's q Theory of Investment

Tobin claims that the rate of investment is related to q, the value of capital relative to its replacement cost. In equilibrium, every firm should have a value of 1 for q. If a firm has value of q above 1 then the firm should stimulate investment in excess of requirements for replacement and normal growth. A value of q below 1 should discourage investment. The q theory of investment is well summarized in Tobin and Brainard (95, p. 242):

The neoclassical theory of corporate investment is based on the assumption that the management seeks to maximize the present net worth of the company, the market value of the outstanding common shares. An investment project should be undertaken if it increased the value of the shares. The securities market appraises the project, its expected contributions to the future earnings of the company and its risks. If the value of the project as appraised by investors exceeds the cost, then the company's share will appreciate to the benefit of existing shareholders. That is, the market will value the project more than the cash used to pay for it. If new debt or equity securities are issued to raise the cash, the prospectus leads to an increase of share prices.

The essential insight underlying Tobin's q theory of investment is that, in a taxless world, firms invest so long as each dollar spent purchasing capital raises the market value of the firm by more than one dollar. The most important characteristic of the q theory of investment is that it can be derived by assuming that firms face adjustment costs and make investment and output decisions with the objective of maximizing market value. In other
words, the modified neoclassical theory of investment with adjustment costs and the q theory of investment are equivalent.

Lucas and Prescott (70) were the first to recognize this. Yoshikawa (100) showed that the optimal rate of investment is the rate for which $q-1$ is equal to the marginal cost of installment under the assumptions of static expectation and the constant return-to-scale technology. Hayashi (43) shows the equivalence of the two theories of investment in a more general model of the firm's present value maximization and derives the optimal rate of investment as a function of $q$.

**The Microeconomic Foundations of the q Theory of Investments**

In this section, Hayashi's argument (43) that the q theory of investment can be derived by the models of neoclassical theory of investment with adjustment cost will be summarized. Consider a firm acting to maximize the present value of future after-tax net receipts:

$$W(t) = \int_0^\infty R(t) \exp[-\int_0^t r(s) ds] dt \quad (2-43)$$

where $r(s)$ is the nominal discount rate. Hayashi defined $R(t)$ as profits after tax plus depreciation tax deductions minus purchases of investment goods plus investment tax credits (43, p. 214):
\begin{equation}
R(t) = [1 - U(t)]\pi(t) + U(t)\int_0^\infty D(x, t-x) u(t-x)I(t-x)dx - [1 - i(t)]u(t)I(t) \tag{2-44}
\end{equation}

where \( \pi(t) \) is profits before tax at \( t \), \( U(t) \) is corporate tax rate, \( D(x, t-x) \) is depreciation allowance per dollar of investment for tax purposes on assets of age \( x \) according to the tax code that was in effect at time \( t-x \), \( u(t) \) is the price of investment goods, \( I(t) \) is investment, and \( i(t) \) is the rate of investment tax credit.

Profits, \( \pi(t) \), are defined as following (43, p. 215):

\begin{equation}
\pi(t) = p(t)F(K(t), L(t)) - w(t)L(t) \tag{2-45}
\end{equation}

where \( p(t) \) and \( w(t) \) are the prices of output and factor inputs at time \( t \). \( F \) is a production function. \( K(t) \) and \( L(t) \) are capital stock and the vector of variable factor inputs respectively.

The following capital accumulation constraint is used instead of the the equation, \( \dot{K} = I - \delta K \).

\begin{equation}
\dot{K} = \gamma(I, K(t)) - \delta K \tag{2-46}
\end{equation}

Unlike previous studies by Gould (38), and Treadway (96), Hayashi introduced adjustment cost into the above capital accumulation equation (2-46). In this formulation, \( I \) units of gross investment do not necessarily turn into capital: only \( \gamma \times 100 \) percent of investment does. \( \gamma \) is assumed to be increasing and concave in \( I \).
Thus, the firm's problem is to maximize equation (2-43) as defined by equation (2-45) subject to the capital accumulation constraint denoted by equation (2-46). By substituting equations (2-44) and (2-45), equation (2-43) can be reduced to

\[ W(0) = \int_{0}^{\infty} [(1-U)\pi - (1-i-Z)uI] \exp[-\int_{0}^{t} rds] dt + \int_{0}^{\infty} U(t) \int_{-\infty}^{\infty} D(t-v, v)u(v)I(v)dv \exp[-\int_{0}^{t} rds] dt \] (2-47)

where \( Z(t) = \int_{0}^{\infty} U(t+x)D(x, t) \exp[-\int_{0}^{t} r(t+s)ds] dt \). The second term in equation (2-47) represents the present value of current and future tax deductions attributable to past investments, referred to \( A(0) \). Since \( A(0) \) is independent of current and future decisions by the firm, the optimization problem is equivalent to maximizing the first term in equation (2-47) with respect to \( I \) and \( L \) subject to equation (2-46). Note that the production function is not constrained in Hayashi's treatment. The Maximum principle approach is adopted to solve the problem.

The first order conditions for optimality are (43, p. 217):

\[ \pi_L = 0 \] (2-48)

\[ (1 - i - Z)u = \lambda \psi_I \] (2-49)

\[ \lambda K(t) = (r + \delta - \psi_k) - (1 - U) \pi_K \] (2-50)

\[ \lim_{t \to \infty} \lambda(t)K(t)\exp(-\int_{0}^{t} rds) = 0 \] (2-51)
where $\lambda$ is the shadow price for constraint (2-46). Equation (2-48) is the marginal productivity condition. Equation (2-50) states that $\lambda$ is the present value of additional future profits that are due to one additional unit of current investment. Equation (2-49) can be rewritten as following:

$$(1 - i)u + (1 - \psi)\lambda = \lambda + Zu \quad (2-49')$$

Here, the first term of the lefthand side of equation (2-49') is the acquisition price of new investment goods from the viewpoint of the firm. The second term of the lefthand side of (2-49') represents adjustment costs associated with investment. The second term of the right hand side of equation (2-49') is the present value of tax deductions due to one unit of current investment. Thus, (2-49') states that the marginal benefit of installing one unit of new investment goods is equal to the marginal cost of doing so.

Tobin's q can be defined as following:

$$\text{marginal } q = \frac{\lambda}{u} = q_m \quad (2-52)$$

$$\text{average } q = \frac{W}{uK} = q. \quad (2-53)$$

Using the above definitions, equations (2-49) and (2-50) can be rewritten as follows (43, p. 217):

$$\frac{1}{\psi} = q/(1 - i - z) \quad (2-49'')$$

$$q = (r + \delta - \hat{\pi} - \psi_k)q - (1 - U) \pi_k/u \quad (2-50')$$
where \( \hat{u} = \hat{u}/u \). We can solve (2-49) for \( I \) to obtain the optimal investment rule:

\[
I = \alpha(\tilde{q}, K; t) \tag{2-54}
\]

where \( \tilde{q} \), modified \( q \), is defined as \( q/(1-i-Z) \). Hayashi claimed (43, p. 218) that "All the information about the demand curve for the firm's output and the production function that are relevant to the investment decision is summarized by \( q \)." Hayashi also showed that if the installation function, \( \psi \), exhibits linear homogeneity in \( I \) and \( K \), then (2-54) is reduced to \( I/K = \beta(\tilde{q}; t) \).

**Application of Tobin's q Theory of Investment**

Tobin's \( q \) has often been used as an explanatory variable to evaluate the monopoly status of a firm in its market. Lindenberg and Ross (66) used \( q \) to assess the monopoly rents of a firm. Smirlock et. al. (88) also used \( q \) to examine the empirical relationship between firm rents and market structure. Chappell and Cheng (15) considered whether \( q \) ratio signals favorable opportunities for a firm to make acquisitions. All of these studies found \( q \) ratio useful in measuring a firm's monopoly power and for evaluating the profitable investment opportunities available.
Lindenberg and Ross.-- These two argue that the difference between the market value of the firm and its replacement cost could be used as a measure of monopoly rents. For a competitive firm, \( q \) would be close to one, and for firms with increasing monopoly power, \( q \) should increase. In case of free entry, \( q \) will be driven down to one as new firms enter the same industry. However, a monopolist who can successfully deter the entry of another firm will earn monopoly rents in excess of ordinary rents on the employed capital. Thus, \( q \) of a monopolist will be persistently greater than one.

They used \( q \) to examine the extent, distribution, and history of monopoly rents and quasi-rents in industry. They test such a theory by comparing \( q \)-based measures with two traditional approaches to the measurement of monopoly: the Lerner index and the four-firm concentration ratio. Their results indicate that the sectors of the economy that have \( q \) ratios at the high end of the spectrum are often those with distinctive products, uncommon factors of production, or other natural barriers to competition, all of which contribute to monopoly and/or quasi-rent. At the low end, they found either relatively competitive, tightly regulated or dying industries. They also found that while the Lerner index contributes to explaining \( q \), the concentration ratio seemed to have little significance.
Smirlock et. al.-- These authors developed two hypotheses about the extent to which firm rents are due to superior efficiency vis-a-vis market concentration. A traditional interpretation would suggest that market concentration fosters collusion where monopoly rents are achieved by firms in the industry. An efficient structure interpretation asserts that concentration emerges from competition and monopoly rents are earned by only those firms possessing an advantage in production.

The purpose of the Smirlock et. al. paper was to re-examine the empirical relationship between firm rents and market structure in order to assess the validity of these hypotheses. To measure firm rents they used Tobin's q. Smirlock et. al. concluded that the efficient structure hypothesis better describes the relationship between market structure and firm behavior; firms with high market shares earn rents not attributable to concentration.

Chappell and Cheng.-- These authors asserted that Tobin's q ratio signals favorable opportunities for a firm to make acquisitions. They test this hypothesis using Tobin's Tobit analysis. Since a firms' decision to acquire is often motivated by the same stimuli that encourages firms to grow internally, investment theory could be used in the specification of equations to explain acquisitions. The dependent variable is the percentage of assets acquired by
merger to the book value of the firm's total asset in the preceding year. As independent variables, \( q_{t-1} / \bar{q} \), where \( \bar{q} \) is the simple average of firms' q ratio, firm profitability, leverage, liquidity, growth and firm size were used. A separate merger activity equation is estimated for each of sample period, 1971 - 1978.

Their results support the hypothesis that Tobin's q signals profitable opportunities for mergers. They concluded that the market for corporate control might be regarded as efficient, because q and profitability turned out to be very important explanatory variables. They concluded that "assets tend to be transferred to firms where they are highly valued by the market and they will be well managed" (15, p. 41).

**Hasbrouck.**-- This author studied the differences in the financial characteristics of target and non-target control firms using multivariate logit analysis. Control firms were selected by matching using either size or industry groupings. The variables used as explanatory variables were q, size of firm, total financial leverage, long-term financial leverage, current liquidity and net current liquidity.

The results of the study revealed that target firms are characterized by low q ratios and to a lesser extent high current financial liquidity. The reason matching was done
by size or industry alternatively was to discern firm and industry specific effects. The results of size matched analysis reflects both firm and industry specific effects, while industry matched analysis reflects only firm specific result. By comparing size matched analysis to industry matched result, Hasbrouck concluded that the difference in \( q \) is caused by firm-specific effects, while liquidity is industry related.

Summary

The first half of the chapter reviewed whether takeover generates gain. Target firms gain significantly from the announcement of the event regardless of the takeover method used. While bidders of tender offers gain, acquiring firms of merger neither gain nor lose significantly around the announcement date. The validity of legal regulations, the Williams Act, and Antitrust Laws has been questioned. The actions taken by the authorities concerned have not brought about desirable effects on takeover activities. In general, the effects of defensive strategies on the wealth of adopting firms' shareholders were inconclusive. Adoption of anti-takeover charter amendments or changes in the state of incorporation do not have significant effects on the wealth of its shareholders. The exact source of gains from takeover activities cannot be identified. Considering the diversity of internal or external conditions given to the
firms, it would be impossible to find sources which could be applicable to all of the takeover activities. Furthermore, combining two different firms further complicates the picture because of probable synergy effects.

The second half of the chapter dealt with the theory of investment. Takeovers are a type of investment which supplements internal investment. The neoclassical theory of investment seeks an investment rule which maximizes the present value of the firm. A recent version of neoclassical theory of investment which includes adjustment cost has been claimed equal to Tobin's q theory of investment (41). Thus, Tobin's q summarizes information about an investment rule which maximizes firm value. That is, high q firms (q>1) should invest until their q equal to one. Low q firms (q<1) should divest or dissolve. Finally, Tobin's q theory applications in finance were reviewed.
CHAPTER BIBLIOGRAPHY


CHAPTER III

METHODOLOGY

Hypotheses

The main hypothesis of this study is that markets are allocationally efficient. If a market is allocationally efficient, firms invest until they use up all the value increasing projects to enhance the welfare of shareholders. Since the opportunity to invest for a firm is summarized by Tobin's q, it could be used to evaluate whether markets are allocationally efficient. While high q firms should invest (8, 21), low q firms should divest (22, 34, 38) to better allocate the resources of a society. All high q firms may not seek external investments like mergers or acquisitions; internal investments could be undertaken instead of external ones.

In this study, the source of gains from transferring corporate control will not be studied. Instead, the question is whether high q firms are more oriented toward external investments. This will be examined assuming that Tobin's q summarizes firms' opportunities to invest (21). In line with the research objectives and the implications of Tobin's q theory of investment, the following hypotheses are advanced.
Hypothesis 1

There will be a significant difference in Tobin’s $q$ between acquiring firms and control firms. The control firms are those who have not been involved in the market for corporate control. Since firms with high $q$ should invest in an allocationally efficient market, acquiring firms should have higher $q$ than those of a control sample. As noted, all high $q$ firms may not seek external investment. However, external investment is a quicker way to grow than internal investment. Thus, the higher $q$ a firm has, the higher incentive to grow externally.

Hypothesis 2

Since low $q$ firms have incentive to divest, they are more apt to become targets. Some low $q$ firms may find other forms of disinvestment. They could sell off unprofitable divisions (1) or dissolve the whole company. They could also voluntarily divest parts of a firm to grant freedom to the rest (22, 34, 38). Dividing a firm is the mirror image of combining firms; low $q$ firms should be encouraged to do so to increase the wealth of shareholders. Target firms will have lower $q$’s than those of control firms.
Measurement of Tobin's q

Tobin's marginal q is theoretically related to the firm's rate of investment (21, p. 218). However, it is not possible to directly measure Tobin's marginal q. Gordon and Bradford (19) suggested one indirect method of calculating a marginal q. They argued that the capital gain equivalent to a dollar of dividend, \( \alpha \), equals Tobin's marginal q under the assumption that firms are setting dividend policy optimally. If a firm makes use of retained funds to maximize shareholder wealth, the market valuation of an incremental dollar of real investment must be \( \alpha \). They derived estimating procedures for \( \alpha \) adopting modified analysis of portfolio choice to incorporate preferences between the two forms of returns, capital gains and dividends. Unfortunately, their methodology to calculate q does not apply to an individual firm.

Tobin's average q is calculated as a proxy of the marginal q. Even though marginal q is theoretically appropriate, the use of average q in explaining investment has been supported by Tobin and Brainard (42, p. 243). Ciccolo and Fromm (9), Malkiel et al. (31), and Chappell and Cheng (8) all used average q in their studies.

Tobin's q of every experimental firm will be calculated for the year of the announcement date for the most recently preceding year financial information is available. The
value of Tobin's q for the control firm will be calculated for the same calendar year as for the corresponding experimental firm. Differences in fiscal year between firms will be ignored. Since Tobin's q is the ratio of market value to replacement cost of a firm, each should be calculated separately.

**Market Value of a Firm**

Market value of a firm is the sum of the following: common stock, preferred stock, and debts. Recorded year-end common stock market values (COMPUSTAT data item number 85) will be used as a market price of the equity claims. Unlike common equity, preferred stocks are not traded actively. Preferred dividends (COMPUSTAT data item number 19) for the year are divided by Standard and Poors preferred stock yield index to approximate the market value of preferred stock as is done in Lindenberg and Ross (29).

Market value of debt is very difficult to obtain from recorded book data. It depends on the maturity distribution of the firm's bonds, coupon rate and the current yield to maturity. Lindenberg and Ross (29) provide an approximation. In any year \( t \), total recorded book debt, \( B_t \), can be broken down as

\[
B_t = BL_t + BL_t ,
\]

(3-1)
where Bl_t is the debt that will mature before year t + 1 and BL_t is the long-term debt maturing beyond t + 1. It is assumed that the market value of Bl_t is equal to its book value.

The difficulty lies in obtaining the market value of BL_t. Ideally, the market value of BL_t can be estimated for each individual issue using yields associated with the firm's bond rating. Lack of necessary data makes this impossible. Following Lindenberg and Ross (29, p. 11), a maturity distribution of total long term debt is estimated first. The assumptions made by Lindenberg and Ross to estimate a maturity distribution of long-term debt are as follows (29, p. 11): 1) All new long-term debt is assumed to have equal maturity, n years. 2) In any year, t, a firm moves long-term debt due within a year into its short-term account. 3) The total long-term debt at year t is sum of all new debt (NB_j) issued for the last n-1 years where j = t - n + 2, ..., t - 1, t. 4) Before some initial year t_0, new debt issued in the years of j = t_0 - n + 2, ..., t_0 are assumed to be 1/n (B_t_0). 5) No new debt is issued unless total long-term debt is increased. Under these assumptions the value of NB_j for all j > t_0 is calculated as follows:

\[ NB_j = BL_j - BL_{j-1} + NB_{j-n+1}, \text{ if } BL_j > BL_{j-1} \]

\[ NB_j = 0 \text{ otherwise.} \]  
(3-2)
Unfortunately the maturity distribution derived from the above formula may not add up to BL\(_t\). The fraction of reported long-term debt, \(f_{t,t-j}\), newly issued at time \(t-j\) is defined as:

\[
f_{t,t-j} = \frac{NB_{t-\text{directly}}}{\sum_{k=0}^{n-2} NB_{t-k}}, \quad j=0, \ldots, n-2 \quad (3-3)
\]

and is used (instead of \(NB_{t-j}\) directly) to obtain the maturity distribution.

In estimating the maturity distribution, all bonds are assumed to have a ten-year maturity. The reason is to have a sufficient number of sample firms. Many of the firms may have to be dropped from the sample if too long of a maturity is assumed.

After establishing the maturity distribution of the firm's long-term debt, the market value of debt can be estimated by assuming all new debt at time \(t\), of a firm with bond rating \(z\), is issued at par with a coupon rate equal to \(\rho_{t}^{z}\), where \(\rho_{t}^{z}\) is the yield to maturity of a firm's debt at time \(t\).

The market value of a firm's debt (MVB\(_t\)) is estimated from BL\(_t\) and BL\(_t\) by following formula:

\[
MVB_t = BL_t + BL_t \sum_{j=0}^{n-2} f_{t,t-j} \left(\frac{\rho_{t}^{z}}{\rho_{t}}\right)^{-(n-j)} \left[(1+\rho_{t}^{z})\right]^{-(n-j)}
\]

\[
= BL_t + BL_t \sum_{j=0}^{n-2} f_{t,t-j} \left[\text{mvb}(t,t-j)\right] \quad (3-4)
\]
where \( mvb(t, t-j) \) denotes the market value of debt $1 issued new at \( t-j \). The value \( mvb(t, t-j) \) can be rewritten as follows:

\[
mvb(t, t-j) = \sum_{i=1}^{n-j} \frac{\rho_i^z}{(1 + \rho_i^z)^i} + \frac{1}{(1 + \rho_t^z)^{n-j}} (3-5)
\]

and is equal to the present value of future coupons and principal payments evaluated at time \( t \).

**Replacement Cost**

According to Lindenberg and Ross (29, p. 12), replacement cost is defined as "the dollar outlay needed to purchase the current productive capacity of the firm at minimum cost and with the most modern technology available." Therefore, not only inflation but technological advance and real depreciation must be included to determine replacement cost.

The assets of a firm fall into three broad categories: plant and equipment, inventories, and other assets. Other assets include liquid assets such as cash and securities, as well as land. The assets in this category are assumed to have replacement value approximately equal to book value. Total replacement cost at time \( t \), \( RC_t \), is defined as

\[
RC_t = TA_t + RNP_t - HNP_t + RINV_t - HINV_t \quad (3-6)
\]
where $TA_t$ is total assets as reported in year $t$, $HNP_t$ is net plant at its historical value in year $t$ and $RNP_t$ is net plant at replacement cost in year $t$. Both $HINV_t$ and $RINV_t$ are inventories at historical and replacement cost respectively in year $t$. Since the sample period covered in this study is after 1977, replacement cost data are available from SEC 10-K filings. However, as noted in Lindenberg and Ross (29), SEC gave broad leeway in the methodology of estimating replacement value. Parker's method for restating net plant is employed to calculate the estimate of replacement value for net plant (36). Lindenberg and Ross's methods of restating inventories for the FIFO and Average cost method were used, while Parker's algorithm was used to estimate the replacement value of inventories when LIFO was used as inventory valuation method. The details are presented in Chapter IV.

Test of Hypotheses

To test the hypotheses that experimental firms' Tobin's $q$ is significantly higher (or lower for acquired firms) than those of control firms, the paired-comparison $t$-test for the matched samples will be employed. The $t$-test is appropriate for evaluating the difference between the means of two independent random samples. The conditions of independence and randomness are met if sample firms can be assigned at random to two groups of firms (10, p. 17). Most
observational studies (like this) have difficulty in finding two independent random samples, since two groups, experimental and control, are formed by forces beyond the researcher's control. That is, firms decide themselves whether to merge or not.

Other assumptions of the t-test are concerned with the population distributions of the variables, Tobin's q. It is assumed that both samples (experimental and control) are from populations in which Tobin's q are normally distributed and their population variances are equal (14, p. 214). Moderate departures from these two assumptions in the data have been known to have little effect on the validity of the test (14, p. 214).

The most important assumption of the t-test is to have two independent random samples (14). The problem is how to perform the t-test without having two independent random samples.

The Effects of the Violation of Two Independent Random Samples Assumption on the Validity of the t-test

When there are two independent random samples, the mathematical representation of the Tobin's q data on the experimental and control group could be as follows:

\[
\begin{align*}
q_{\text{ex}}^j &= m + q + e_{\text{ex}}^j \\
q_{\text{co}}^j &= m + e_{\text{co}}^j
\end{align*}
\]
where \( m \) represents a parameter meaning the average level of Tobin's \( q \) in the control group. \( \theta \) denotes the average effect attributable only to the experimental group of firms. Thus, the mean of Tobin's \( q \) for the experimental group of firms is \( m + \theta \). The variables \( e^\text{ex}_j \) and \( e^\text{co}_j \) are random variations which differ from one firm to another. Both are assumed to have an expected value of zero.

The above model implies an assumption that \( q^\text{ex}_j \) and \( q^\text{co}_j \) are drawn from populations having the same mean \( m \). To ensure that this assumption holds, two independent random samples are needed. If indeed samples are drawn independently and randomly, then the above simple model will be a good representation of the nature of data. What is crucial in the t-test is whether \( \theta \) are zero or not. If \( \theta \) is found to be significantly different from zero, then experimental firms' Tobin's \( q \) are said to be significantly different from those of control firms.

The simple estimate of \( \theta \) is \( \bar{d} = \bar{q}^\text{ex} - \bar{q}^\text{co} \). If equation (3-1) is assumed, then \( \bar{d} = \theta + \bar{e}^\text{ex} - \bar{e}^\text{co} \) and \( E(\bar{d}) = \theta \). If \( e^i_j \) is assumed normally and independently distributed, then \( \bar{d} \) is also normal with population mean \( \theta \) and standard deviation of \( \sigma \sqrt{2/n} \). Estimate of \( \sigma^2 \), \( s^2 \), can be made from the pooled within-group mean square, where

\[
\frac{\sum (q^\text{ex}_j - \bar{q}^\text{ex})^2 + \sum (q^\text{co}_j - \bar{q}^\text{co})^2}{2 (n - 1)}
\]

(3-8)
and the quantity $(\bar{d} - \theta)/s\sqrt{\pi/n}$ will follow a t distribution with $2(n-1)$ degrees of freedom (10, p. 18).

As stated earlier, this study cannot perform an independent random sampling because of restrictions on the control of the researcher. This means that the above representation of the data does not fit well for the data of this study. A more realistic model would be like the following (10, pp. 25-26):

$$q_{ex}^j = m_{ex} + \theta + e_{ex}^j$$

$$q_{co}^j = m_{co} + e_{co}^j$$

(3-9)

with $E(e_{ex}^j) = E(e_{co}^j) = 0$ as before. In this model, $m_{ex}$ is not assumed to be equal to $m_{co}$ since samples are not independent and random. $\bar{d}$ will be as follows:

$$\bar{d} = \bar{q}_{ex} - \bar{q}_{co} = \bar{\theta} + (m_{ex} - m_{co}) + (\bar{e}_{ex} - \bar{e}_{co}).$$

(3-10)

The expected value of $\bar{d}$, $E(\bar{d})$, is $\theta + (m_{ex} - m_{co})$ which is different from $\theta$. The quantity $m_{ex} - m_{co}$ denotes bias. Once the presence of bias is recognized, the level of the test is not the same as with the case of no bias (10, p. 26). If the exact amount and the direction of bias are known a priori, then there is no problem. In practice, it is very rare to be certain about the direction and the amount of bias in observational studies, let alone to have estimates completely free from bias. The problem is to keep the bias
small enough so that the implications are not misinterpreted. Cochran (10, p. 29) claimed that "the positive attitude toward this problem is to exercise precautions against bias in the planning and analysis of observational studies, in the hope that the remaining bias will not greatly disturb type-one error or confidence probabilities."

Possible Sources of Bias

Bias was defined as the difference of population means for the two groups of firms' Tobin's q. Since Tobin's q may be influenced by numerous other variables, it would be likely to have at least one or more of the confounding variables which may differ systematically from population to population. This systematic difference in confounding variables will result in the difference in population means, introducing bias. This bias has been shown to be detrimental to the validity of statistical tests.

By controlling undesirable effects of confounding variables, bias can be reduced. Before finding methods of reducing bias, it is important to check what kinds of confounding variables will affect the value of Tobin's q. Many variables which are related to the characteristics of a specific firm like various financial ratios, dividend policy, and characteristics of a firm's industry are likely to affect the value of Tobin's q. Considering all the
possible confounding variables is not only impossible, but impractical. As in an equilibrium asset pricing model (2, 3), a few variables seem to capture a major portion of bias. The following three variables are considered as the major confounding variables to affect the value of Tobin’s q: responsiveness to the trend of market, industry classification, and the size of a firm.

Responsiveness to market movement.-- If every firm is affected by the trend of the market equally, then there will be no bias resulting from the systematic differences in responsiveness of the two groups of firms, experimental and control. However, it would be reasonable to assume that every firm will be affected differently by the market trend as in Capital Asset Pricing Model. As a result, responsiveness to the market trend of the experimental group may differ systematically from that of the control group. Thus, there is a need to adjust for this systematic difference to reduce bias.

Industry Classification.-- One industry group may have its own characteristics which are systematically different from those of other industries, resulting in a different distribution of the value of Tobin’s q. If two groups of firms, experimental and control, include the same number of firms in a specific industry in their sample, no systematic difference should result.
Size of a Firm.-- It is conceivable to think of size as a confounding variable which affects the value of Tobin's q, even when two firms have similar market responsiveness and are grouped in a same industry. Big firms may have monopoly power resulting in a higher Tobin's q (29). Conversely, smaller firms may not have enough power to resist the entry of potential competitors leading to lower q's. If the sizes of firms included in one group systematically differ from those of the other, bias could result.

Equation (3-8) can be modified to include a confounding variable $x$. Assuming $q$ has the same linear relationship on a confounding variable $x$ for both groups of firms, $m_{ex}$ and $m_{co}$ in equation (3-8) can be rewritten as follows:

\[
\begin{align*}
  m_{ex} &= a + bx_{ex} \\
  m_{co} &= a + bx_{co}.
\end{align*}
\]  \hspace{1cm} (3-11)

Using the equation (3-10), equation (3-8) can be rewritten as follows:

\[
\begin{align*}
  q_{ex} &= a + bx_{ex} + \bar{e}_{ex} + \theta \\
  q_{co} &= a + bx_{co} + \bar{e}_{co}.
\end{align*}
\]  \hspace{1cm} (3-12)

The sample mean difference $d$ is:

\[
\bar{d} = \bar{q}_{ex} - \bar{q}_{co} = \theta + b(\bar{x}_{ex} - \bar{x}_{co}) + (\bar{e}_{ex} - \bar{e}_{co}) \]  \hspace{1cm} (3-13)

and the expected value of $\bar{d}$, $E(\bar{d})$, is:

\[
E(\bar{d}) = \theta + b \{m(x)^{ex} - m(x)^{co}\}. \]  \hspace{1cm} (3-14)
So, \( b(m(x)^e - m(x)^c) \) denotes the amount of bias.

**Techniques to Reduce Bias**

There are two principal techniques to reduce bias (10), matching and adjustment in analysis. Both attempt to control undesirable effects of confounding variables. The matching technique reduces bias by selecting \( x^e_x \) and \( x^c_o \) such that they are equal. The other reduces bias by estimating \( b \) and subtracting \( \hat{b}(x^e_x - x^c_o) \) from \( \bar{d} \), i.e., \( \bar{d} = \bar{d} - \hat{b}(\bar{x}^e_x - \bar{x}^c_o) \). Their difference lies in what stage the confounding variables are handled. In matching, confounding variables are treated at the planning stage--the other handles confounding during analysis.

**Matching.**-- Each member of the experimental group has a partner in the control group, where the partners are within the defined limits in the values of confounding variables included. In other words, matching is used to make two groups of firms resemble each other in certain respects so that the two groups of firms have closer population means. One restriction of matching is that the regression coefficient \( b \) should be the same in both groups of populations. Among the three confounding variables described above, industry classification and the size of a firm can be controlled at the planning stage, by matching.
Adjustments for the Market Trend.-- When the b's in equation (3-11) are different in two groups, matching cannot be employed. Thus, market trend should be adjusted for during analysis (as is done when calculating risk-adjusted, abnormal returns). Lindenberg and Ross (29) devised adjustment methods which run regressions for each firm in the sample. The important issue is how two groups of firms (experimental and control) differ in their responsiveness to the general trend of market collectively, not individually. Further, there may be many firms with insufficient data for regression--COMPUSTAT has, at most, twenty years of data for each firm.

The adjustment will be done by running the following two regression equations:

\[
q_{\text{ex}}^{\text{tj}} = a_{\text{ex}} + b_{\text{ex}}(\overline{q}_t^\text{m} - \overline{q}_{\text{ex}}^\text{tj}) + e_{\text{ex}}^{\text{tj}} \quad j=1,\ldots,n
\]

\[
q_{\text{co}}^{\text{tj}} = a_{\text{co}} + b_{\text{co}}(\overline{q}_t^\text{m} - \overline{q}_{\text{co}}^{\text{tj}}) + e_{\text{co}}^{\text{tj}} \quad j=1,\ldots,n \quad (3-15)
\]

where \(q_{\text{ex}}^{\text{tj}}\) and \(q_{\text{co}}^{\text{tj}}\) are the values of Tobin's q for the jth firm in the experimental and control group respectively at year t, where t denotes the prior calendar year when a firm in the experimental group announces its plan for a takeover. Only one value of Tobin's q is calculated for every firm in the samples. \(\overline{q}_t^\text{m}\), \(\overline{q}_{\text{ex}}^{\text{tj}}\) and \(\overline{q}_{\text{co}}^{\text{tj}}\) are calculated as follows:
The quantity $b_i (\bar{q}_t^m - \bar{q}_t^i)$ represents the variation in $q$ caused by the general trend of the market. And $a_1$ can be viewed as a long run value of Tobin's $q$ for the $i$ group. The difference $\bar{q}^e_t - \bar{q}^c_t$ is

$$\bar{q}^e_t - \bar{q}^c_t = a^e_t - a^c_t + \sum b^e_t (\bar{q}_t^m - \bar{q}_t^e) \frac{n(t)}{N}$$

$$- \sum b^c_t (\bar{q}_t^m - \bar{q}_t^c) \frac{n(t)}{N} + e^e_t - e^c_t . \quad (3-17)$$

It follows that

$$E(\bar{q}^e_t - \bar{q}^c_t) = a^e_t - a^c_t + \sum b^e_t (\bar{q}_t^m - \bar{q}_t^e) \frac{n(t)}{N}$$

$$- \sum b^c_t (\bar{q}_t^m - \bar{q}_t^c) \frac{n(t)}{N} . \quad (3-18)$$

After estimating $\hat{b}^e_t$ and $\hat{b}^c_t$, $\tilde{d} = \bar{q}^e_t - \bar{q}^c_t$ can be adjusted,

$$\tilde{d} = d - (\hat{b}^e_t \sum (\bar{q}_t^m - \bar{q}_t^e) \frac{n(t)}{N}$$

$$- \hat{b}^c_t \sum (\bar{q}_t^m - \bar{q}_t^c) \frac{n(t)}{N}) . \quad (3-19)$$

In the above regression equation (3-15), b's are assumed to be stationary over time.
Prediction of Takeovers

If significantly different means in Tobin's q between the experimental and control groups are observed, then Tobin's q could be used to predict future behavior of firms as to whether they will be prone to merge or not. There are several statistical methodologies in explaining and predicting firm behavior. This study uses probit for the following reasons.

The linear probability model.-- This is a regression model in which the dependent variable is a binary variable taking zero or one depending on the occurrence of the event considered. The model can be written as follows:

\[ y_i = a + bx_i + e_i , \quad i=1, \ldots, n \]  

(3-20)

with the assumption of \( E(e_i) = 0 \). The predicted value \( \hat{y}_i = \hat{b}x_i + a \) implies the probability that the event will occur given the particular value of the independent variable \( x \) where \( a \) and \( b \) are unknown parameters and \( e_i \) is a random disturbance.

This model is simple, but has many problems. Since \( y_i \) can take only the value of zero or one, \( e_i \) also can take only one of two values; they are \( 1-(a+bx_i) \) and \( -(a+bx_i) \). As a result, the respective probabilities of these two \( e_i \)'s should be \( a+bx_i \) and \( 1-(a+bx_i) \) to satisfy the assumption of \( E(e_i) = 0 \). Since \( a+bx_i \) can take any values outside of the admissible range \((0,1)\), the probabilities of \( e_i \) can be
greater than one or less than zero. Further, the variance of $e$, $E(e_i^2)$, is not constant. Because $E(e_i^2)$ is

$$E(e_i^2) = (a+bx)[1-(a+bx)]$$  \hspace{1cm} (3-21)$$

the variance depends on the value of $x$. Therefore, $e$'s are heteroscedastic, which violates the assumption of ordinary least squares. This violation of assumption results in inefficient estimates of $a$ and $b$. Finally, significance tests for the estimated coefficients are not meaningful as the result of using inconsistent estimate of standard error. For these reasons, use of the linear probability model was rejected.

**Discriminant Analysis.**—This also could be used to see whether Tobin's $q$ has enough power to discriminate experimental firms from control firms. Statistically speaking, discriminant analysis is a method of obtaining a set of composite variables (discriminant function) which have the largest between-group variance relative to within-group variance. A powerful discriminant function is useful for prediction purposes. This analysis also has its weaknesses. Discriminant analysis requires normality of independent variables which may not be appropriate for this study. The coefficients of a discriminant function do not have direct implication for the independent variables; they are unique only up to a factor of proportionality (15, p. 882-883).
Probit and Logit Analysis

When a dependent variable can take only two values, zero and one, depending upon the occurrence of an event, the probability of the event occurring is implicitly implied in analyses. The linear probability model assumes that the probability, $P_i$, of an event occurring is simply the expected value of $y_i$ in equation (3-20). As a result, difficulties discussed earlier arise. Probit and logit analysis assume the probability of an event occurring, $P_i$, is a nonlinear function of the explanatory variables.

Two widely used nonlinear probability models are based on the cumulative distributions of normal and logistic random variables, with the associated analysis being called probit and logit analysis. Probit and Logit analysis assume that there is an underlying response variable, $IN_i$, which is linear in $b$, such that the larger the index variable $IN_i$, the greater the probability of the event in question occurring. In practice, $IN_i$ is unobservable. What can be observed is a binary variable, $y_i$, defined by

\[
\begin{align*}
  y_i &= 1 & \text{if an event occurs} \\
  y_i &= 0 & \text{otherwise.}
\end{align*}
\]  

(3-22)

Some kind of monotonic relationship between $IN_i$ and the probability of the event occurring may be used to transform $IN_i$ into cumulative probabilities $P_i$. Probit analysis uses
a normal distribution function; logit employs a logistic cumulative distribution function to transform the index variable $IN_i$ into $P_i(E|IN_i)$.

When there are few repeated observations on the data (in this study only one observation for each firm), maximum likelihood estimation of logit and probit models can be carried out (17, 25). Let $P_i$ be the probability that the event occurs on the $i$th firm, then the random variable $y_i$ has following probability function:

$$
Y_i = 1 \quad \text{with probability } P_i \\
0 \quad \text{with probability } (1-P_i) \quad (3-23)
$$

If the total number of observations, $N$, is available, then the likelihood function would be as in the following:

$$
1 = \prod_{i=0}^{y_i} (1 - P_i) \prod_{i=1}^{P_i} P_i \\
= \prod_{i=1}^{N} P_i^{y_i} (1-P_i)^{1-y_i} \quad (3-24)
$$

Since $P_i$ is monotonically transformed value of $IN_i$, $P_i$ is $F(a+bx_i)$ where $F$ denotes the cumulative distribution function. Thus, the likelihood function for the model is

$$
1 = \prod_{i=1}^{N} [F(a+x_i b)]^{y_i} [1-[F(a+x_i b)]]^{1-y_i} \quad (3-25)
$$

and the log-likelihood function is
\[
\ln l = \sum_{i=1}^{N} \left( y_i \ln [F(a+x_ib)] + (1-y_i) \ln [1 - F(a+x_ib)] \right) \quad (3-26)
\]

Since the first order conditions for a maximum will be nonlinear for both probit and logit analysis, the estimation of coefficients must be obtained numerically, i.e., by employing iterative procedures. This procedure will be performed by SHAZAM of the University of British Columbia.

One thing to note in the interpretation of the estimated coefficients is that the coefficients do not indicate the changes in the probability of the event occurring given one unit change in the corresponding variables (25). Rather, the partial derivative, \( P_{x_i} \), where \( P = F(xb) \) is

\[
\frac{\partial P}{\partial x} = f(xb)b \quad (3-27)
\]

where \( f(\cdot) \) is the associated probability density function of \( F \). Thus, while the sign of a coefficient indicates the direction of the change, the magnitude depends not only on the coefficient, but on \( f(xb) \). Probit and logit equations will be estimated for each year of the sample period, 1977 - 1983.

Problems related to the choice based sampling.-- Manski and Lerman (33) claimed that the estimation of the
parameters of a probabilistic choice model has a problem when choices rather than decision makers are sampled. While exogenous random sampling selects decision makers first and their choice behaviors are observed next, a choice-based sampling reverses the order. Manski and Lerman (33) showed that the maximum likelihood estimators appropriate to choice-based sampling are not computationally tractable. They also showed that two particular sampling methods, random choice based sampling and random exogenous sampling, have the same likelihood functions.

To have a random choice based sampling, the sample share for a particular choice should be equal to the population share for the same choice. In other words, the ratio of experimental firms to control sample firms should be in line with the ratio of such firms in the economy as a whole. This point was also recognized by Harris et. al. (22, p. 168).

Though it is hard to estimate population share correctly, the number of firms involved in takeover activities seems a lot less than that of firms who are not. However, this study will select the same number of firms for both groups of firms by matching. This deviation of sample share from population share may produce misleading results in the coefficients estimates. To alleviate the problem, the estimation will be done year by year. If mergers
occurred evenly during the whole sample period, then the number of mergers which happened in a year will be about one seventh of total firms. To estimate probit and logit coefficients for a year, only experimental firms who merged in the year will be included in the analysis along with all the control sample firms selected. Thus, the sample share would be one-eighth and seven-eighth respectively for experimental firms and control firms.

Sample Design

To test the hypotheses described above, two groups of sample firms, experimental and control firms, will be selected.

Selection of Experimental Firms

There are two groups of firms in the experimental group. One group of firms is acquiring firms and the other is target firms. Acquired firms will be selected by using the COMPUSTAT research tape. The research tape contains data for 1366 firms which were deleted from Industrial Compustat tape. Among them 1022 firms were deleted because of merger and acquisitions. Seven hundred sixty firms out of 1022 firms merged after 1977. Since Tobin's q cannot be measured without replacement cost data, the time period will be restricted to only after 1977. The reason 1977 was selected as the beginning sample period is that the SEC
began requiring replacement cost data from 1976. If 1976 were used as the beginning year, then data for 1975 might have to be used to calculate the value of Tobin's q. Thus, only mergers which occur after 1977 are included in this study.

The COMPUSTAT research tape has several files such as the primary file (S&P 400), primary file (non S&P 400), tertiary, and supplementary file. The distribution of 760 firms into these files are 6, 230, 237 and 287 firms respectively. Only two primary files listed firms, 236 (6 + 230), will be used as experimental target firms. To calculate Tobin's q, the market value of common stock is needed. Thus, only NYSE listed firms, 222, are included as target firms. Another restriction is industry grouping. Only mining and manufacturing firms are included as sample target firms. One hundred and seventy one firms out of 222 firms have the desired SIC codes (From 1000 to 1499 and from 2000 to 3999).

Acquiring firms corresponding to those target firms selected will be identified by the Wall Street Journal Index, along with the announcement date of merger plans. The announcement date is used to determine which year of data to use to calculate Tobin's q. Tobin's q is calculated for the fiscal year of the announcement date. Seventy-one acquired firms are found to satisfy all the restrictions
made. The main restrictions are: 1) Acquiring firm should be listed on the industrial COMPUSTAT tape, 2) At least ten years of data should be available for an acquiring firm. Appendix A lists the names of seventy one acquiring and acquired firms together with their SIC industry codes.

**Selection of Control Firms**

Control firms are matched for each member of the experimental group of firms. To qualify as a control firm a firm should not be involved in major takeover activities. A firm who has not been involved in takeover activities for the year of merger announcement may be a control firm. Matched firms for the experimental firms (acquiring and acquired firms) are selected from the firms in COMPUSTAT which have the same SIC code and similar size.

At first, all four digits of the SIC code are used. When there is no firm available which satisfies general criterions specified above, a three-digit SIC code is used to find a matching firm. When there are several firms who have same SIC code with that of experimental firm, size of a firm is employed to choose a matching firm. Size is measured by the total assets in the financial statement, plus or minus 10 percent of the total assets of the experimental firm (caliper matching). If there are no firms whose total assets are within the 10 percent range (although they have the same SIC code), then the range is increased by
10 percent each time until the range becomes 50 percent. When no match firm is available even after the range is increased to 50 percent, the next smaller SIC code is used to find a control firm. The matched firms selected by applying the above rules are listed in Appendix B.

Summary

This chapter starts with the research hypotheses derived from the implication of the theory of investment under the condition of allocationally efficient market. In an allocationally efficient market all the value increasing projects should be undertaken to increase the wealth of shareholders. The incentive of a firm to invest can be summarized by Tobin's q (21, 43). Acquiring firms (targets) should have a higher (lower) q than that of control firms, if the market is allocationally efficient.

The measurement scheme for Tobin's q is presented next. The Lindenberg and Ross methodology is employed to calculate average Tobin's q, with slight modifications. Parker's methods were used to estimate replacement values for net plant and inventories when LIFO was the inventory valuation method. When FIFO and Average cost methods were used, Lindenberg and Ross's method will be used. For consistency, all replacement value estimates will be calculated by the methods described before, not using the estimates reported in SEC 10-K reports. For many firms, the estimates were not available in the 10-K reports.
Hypotheses testing methodologies, t-test and probit (or logit) analyses are presented with their assumptions and limitations. Adjustment schemes for the violations of the assumptions are also presented. The major problem in this study is the difficulty of obtaining two independent random samples. This problem will be controlled for by finding matched control firms which have similar characteristics with the experimental firms. Three confounding variables are used to control undesirable effects of choice-based sampling. Size and industry classifications are used to find a matched control firm. The difference in the responsiveness to the market trend is handled by adjustment in the statistical analysis. Finally, sample selection procedures are discussed.
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CHAPTER IV

PRESENTATION OF RESULTS AND TESTS OF HYPOTHESES

This chapter presents the results of several procedures needed to calculate adjusted Tobin's q and the outcomes of the hypotheses tests. The first part of the chapter concerns the methods and results of estimating a maturity distribution and quality ratings of long-term debts. The methods to estimate replacement cost of net plant and inventories are also presented.

The second part summarizes average q-values of four groups (targets, acquirers, and two control groups) for two different weights (equal and market weights). The results of adjustment regressions using individual and average q-values are reported. Finally, the results of normality tests, paired comparison t-tests and probit estimations are reported, together with the findings of the study.

Calculation of Tobin's q

To calculate Tobin's q, market values and replacement costs of sample firms are needed. Market values of preferred and common stock were calculated by the methods described in Chapter III. Upon request, Standard and Poors provided a preferred stock yield index. The average yields for preferred stocks for the years of 1976 through 1982 were 0.0798, 0.0761, 0.0825, 0.0911, 0.1060, 0.1236, and 0.1253.
Preferred dividend data were not available for one sample firm and this firm was deleted from the sample. Unlike the calculation of market values for preferred and common stock, market value of bonds was calculated by employing several steps. First, a maturity distribution of long-term debts were estimated.

An Estimation of Maturity Structure of Long-Term Debts

Ideally, market value of long-term debt, $BL_t$, can be estimated for each individual issue using yields associated with the firm's bond rating. Since lack of data makes this impossible, there is a need to break $BL_t$ into issues of different maturities.

To estimate a maturity distribution of long-term debt, $BL_t$, the following assumptions made by Lindenberg and Ross (18, p. 11) were used in the study: 1) All new debts have equal maturities (ten years) and long-term debt due within a year is regarded as short-term debt. 2) The long-term debt outstanding at time $t$, $BL_t$, is a sum of all new debts issued ($NB_{t-j}$) for the last n-1 years from $t-n+2$ to $t$. 3) No new debt is issued unless total long-term debt is increased.

Following the above assumptions, new debt issued at time $t-j$, $NB_{t-j}$ for all $t-j > t_o$ ($t_o = 1968$) was estimated by Equation (3-2).
\[ NB_{t-j} = BL_{t-j} - BL_{t-j-1} + NB_{t-j-n+1} \]

if \( BL_{t-j} > BL_{t-j-1} \)

\[ NB_{t-j} = 0 \]

otherwise \hspace{1cm} (3-2)

where \( BL_{t-j} \) denotes the long-term debt outstanding at time \( t-j \). New debts issued before the initial year \( t_0 = 1968 \) were assumed to be \( 1/n(B_{t_0}) \) where \( B_{t_0} \) is the total debt outstanding at time \( t_0 \).

A check was made to see whether the sum of \( NB_{t-j} \) from \( j=n-2 \) to \( j=0 \) is close to the amount of long-term debt at time \( t \). Table I presents the average proportion of \( \sum_{j=0}^{n-2} NB_{t-j} \) to long-term debt outstanding at time \( t \) for all sample firms.

**TABLE I**

**AVERAGE PROPORTIONS OF THE SUM OF ESTIMATED LONG-TERM DEBT TO THE REPORTED LONG-TERM DEBT OUTSTANDING AT TIME \( t \)**

<table>
<thead>
<tr>
<th>Sample Groups</th>
<th>The Mean Value of the sum of estimated long-term debt in COMPUSTAT (1)</th>
<th>Reported long-term debt (2)</th>
<th>The Average Proportions (3)=(1)/(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Targets</td>
<td>167.8</td>
<td>171.3</td>
<td>0.98</td>
</tr>
<tr>
<td>Acquirers</td>
<td>636.4</td>
<td>682.4</td>
<td>0.93</td>
</tr>
<tr>
<td>Target Control</td>
<td>173.0</td>
<td>172.5</td>
<td>1.00</td>
</tr>
<tr>
<td>Acquirer Control</td>
<td>536.6</td>
<td>564.6</td>
<td>0.95</td>
</tr>
<tr>
<td>Total</td>
<td>378.5</td>
<td>397.7</td>
<td>0.95</td>
</tr>
</tbody>
</table>
These proportions for each group of firms are also presented. The year \( t \) denotes the merger announcement date for each of sample mergers.

Table I shows that Lindenberg and Ross's methodology to estimate a maturity distribution of long-term debts produce reasonable results when a ten year maturity is assumed. The average proportion of \( \sum_{j=0}^{n-2} \frac{1}{n} NB_{t-j} \) to the outstanding long-term debts was 95 percent for all sample firms.

Although the proportions are reasonably close to one, the fractions \( f_{t,t-j} \), estimated long-term debt newly issued at time \( t-j \) \((NB_{t-j})\) to the sum of estimated long-term debt \( \left( \sum_{j=0}^{n-2} NB_{t-j} \right) \), were calculated to be used in the estimation of market value of bonds represented by Equation (3-4):

\[
MVB_t = B1 + BL_t \sum_{j=0}^{n-2} f_{t,t-j} (mvb(t,t-j))
\]

where \( MVB_t \) is market value of bond at time \( t \), \( mvb(t,t-j) \) is the market value of debt \$1 issued new at time \( t-j \) and \( B1 \) is the short-term debt outstanding at time \( t \). Table II presents the average of \( f_{t,t-j} \) across the sample groups. The values of \( f_{t,t-j} \) in recent four years \((j=0 \text{ to } 3)\) are consistently larger than those of remote years \((j=4 \text{ to } 8)\) in all groups. Most notably, the acquiring firms had the highest \( f \) values in the most recent four years. The acquired firms had the smallest values of \( f_{t,t-j} \) in the most recent four years.
TABLE II
AVERAGE VALUE OF THE FRACTIONS OF THE ESTIMATED LONG-TERM DEBT NEWLY ISSUED AT t-j TO THE SUM OF ESTIMATED LONG-TERM DEBTS

<table>
<thead>
<tr>
<th>j</th>
<th>Targets</th>
<th>Acquirer</th>
<th>Target Control</th>
<th>Acquirer Control</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>0.1141</td>
<td>0.0794</td>
<td>0.0660</td>
<td>0.0679</td>
<td>0.0819</td>
</tr>
<tr>
<td>7</td>
<td>0.0983</td>
<td>0.0839</td>
<td>0.0683</td>
<td>0.0802</td>
<td>0.0827</td>
</tr>
<tr>
<td>6</td>
<td>0.0677</td>
<td>0.0857</td>
<td>0.1123</td>
<td>0.1055</td>
<td>0.0928</td>
</tr>
<tr>
<td>5</td>
<td>0.1086</td>
<td>0.0969</td>
<td>0.0760</td>
<td>0.0931</td>
<td>0.0937</td>
</tr>
<tr>
<td>4</td>
<td>0.0994</td>
<td>0.0936</td>
<td>0.0958</td>
<td>0.0870</td>
<td>0.0940</td>
</tr>
<tr>
<td>3</td>
<td>0.1333</td>
<td>0.1204</td>
<td>0.1231</td>
<td>0.1103</td>
<td>0.1218</td>
</tr>
<tr>
<td>2</td>
<td>0.1457</td>
<td>0.1259</td>
<td>0.1197</td>
<td>0.1753</td>
<td>0.1417</td>
</tr>
<tr>
<td>1</td>
<td>0.1164</td>
<td>0.1754</td>
<td>0.1520</td>
<td>0.1065</td>
<td>0.1376</td>
</tr>
<tr>
<td>0</td>
<td>0.1163</td>
<td>0.1386</td>
<td>0.1422</td>
<td>0.1520</td>
<td>0.1373</td>
</tr>
</tbody>
</table>

Prediction of Bond Ratings

To estimate market value of long-term debts, yields to maturity for the period of 1968 to 1982 are needed. Moody’s Bond Records estimated the monthly yields of bonds for four different qualities of bonds, Aaa, Aa, A, and Baa. The bond ratings data for the sample firms were collected from Moody’s Bond Records, to identify the appropriate yield to maturity of sample firms’ bonds. Unfortunately, there were many sample firms whose bond ratings were not available. Table III summarizes the bond ratings of the issues of sample firms for which ratings were available. Out of 180 total sample firms only forty-nine ratings were available in
1968. In 1975, the available number of ratings increased to 122. Since 1976, the number decreased because the number of target firms existing decreased.

**TABLE III**

**DISTRIBUTION OF SAMPLE FIRM BOND RATINGS**

(WHERE AVAILABLE)

<table>
<thead>
<tr>
<th>Year</th>
<th>Aaa</th>
<th>Aa</th>
<th>A</th>
<th>Baa</th>
<th>Ba</th>
<th>B</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>2</td>
<td>5</td>
<td>13</td>
<td>9</td>
<td>15</td>
<td>5</td>
<td>49</td>
</tr>
<tr>
<td>1969</td>
<td>4</td>
<td>6</td>
<td>15</td>
<td>10</td>
<td>19</td>
<td>3</td>
<td>57</td>
</tr>
<tr>
<td>1970</td>
<td>4</td>
<td>7</td>
<td>20</td>
<td>9</td>
<td>23</td>
<td>4</td>
<td>67</td>
</tr>
<tr>
<td>1971</td>
<td>3</td>
<td>6</td>
<td>15</td>
<td>10</td>
<td>26</td>
<td>17</td>
<td>77</td>
</tr>
<tr>
<td>1972</td>
<td>3</td>
<td>6</td>
<td>14</td>
<td>15</td>
<td>27</td>
<td>19</td>
<td>84</td>
</tr>
<tr>
<td>1973</td>
<td>3</td>
<td>8</td>
<td>19</td>
<td>16</td>
<td>33</td>
<td>21</td>
<td>100</td>
</tr>
<tr>
<td>1974</td>
<td>5</td>
<td>9</td>
<td>17</td>
<td>20</td>
<td>31</td>
<td>24</td>
<td>106</td>
</tr>
<tr>
<td>1975</td>
<td>7</td>
<td>9</td>
<td>25</td>
<td>23</td>
<td>32</td>
<td>26</td>
<td>122</td>
</tr>
<tr>
<td>1976</td>
<td>7</td>
<td>10</td>
<td>26</td>
<td>20</td>
<td>30</td>
<td>26</td>
<td>119</td>
</tr>
<tr>
<td>1977</td>
<td>5</td>
<td>11</td>
<td>25</td>
<td>20</td>
<td>29</td>
<td>27</td>
<td>117</td>
</tr>
<tr>
<td>1978</td>
<td>5</td>
<td>8</td>
<td>20</td>
<td>15</td>
<td>26</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>1979</td>
<td>5</td>
<td>8</td>
<td>20</td>
<td>10</td>
<td>23</td>
<td>18</td>
<td>84</td>
</tr>
<tr>
<td>1980</td>
<td>5</td>
<td>11</td>
<td>17</td>
<td>13</td>
<td>22</td>
<td>16</td>
<td>84</td>
</tr>
<tr>
<td>1981</td>
<td>4</td>
<td>7</td>
<td>17</td>
<td>15</td>
<td>20</td>
<td>12</td>
<td>75</td>
</tr>
<tr>
<td>1982</td>
<td>3</td>
<td>11</td>
<td>12</td>
<td>18</td>
<td>14</td>
<td>12</td>
<td>70</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>122</td>
<td>275</td>
<td>223</td>
<td>370</td>
<td>255</td>
<td>1310</td>
</tr>
</tbody>
</table>

Considerable work has been done to predict agency-assigned bond ratings (2, 25, 26, 27). Perry, Cronan, and Henderson (25) suggest that use of ordinal, rather than interval, data and industry classification, generally, improves the predictive ability of bond rating models which employ Multiple Discriminant Analysis. Too few sample firms were available for many industries, so industry classifications could not be used in this study.
The discriminating variables used in Perry, Cronan, and Henderson (25) were used in this study. Table IV lists the discriminating variables.

Five different characteristics (liquidity, leverage, activity, size, and profitability) and the variability of these attributes were measured. Among thirty-three variables, there are nine liquidity measures, five leverage measures, five activity measures, six profitability measures, one size variable, and another seven variables which measure the mean and variability of size, liquidity and leverage.

Using SAS PROC STEPDISC stepwise procedures (30), a set of variables were chosen as candidates for variables which gave better discriminant models for each year from 1968 to 1982. The SAS procedure selected a subset of the thirty-three discriminating variables for each year which gave a good discriminating model using stepwise selection methods. This stepwise selection method starts with no variables and, at each step, the variable that most contributes to the discriminating power of the model is entered. Any variable already in the model that no longer meets the criterion to stay is removed. This process continues until no variables meet the criterion to enter and all variables in the model meet the criterion to stay.
## TABLE IV

### BOND RATING DISCRIMINATING VARIABLES

<table>
<thead>
<tr>
<th>Variable Number</th>
<th>Variable Name</th>
<th>Description** ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LIQ1</td>
<td>x4/x6</td>
</tr>
<tr>
<td>2</td>
<td>LIQ2</td>
<td>(x1+x2)/x5</td>
</tr>
<tr>
<td>3</td>
<td>LIQ3</td>
<td>x13/x6</td>
</tr>
<tr>
<td>4</td>
<td>LIQ4</td>
<td>(x4-x5)/x6</td>
</tr>
<tr>
<td>5</td>
<td>LIQ5</td>
<td>x4/x6</td>
</tr>
<tr>
<td>6</td>
<td>LIQ6</td>
<td>(x18+x14)/x11</td>
</tr>
<tr>
<td>7</td>
<td>LIQ7</td>
<td>x5/x6</td>
</tr>
<tr>
<td>8</td>
<td>LIQ8</td>
<td>x13/x15</td>
</tr>
<tr>
<td>9</td>
<td>LIQ9</td>
<td>(x13-x14)/x15</td>
</tr>
<tr>
<td>10</td>
<td>LEV1</td>
<td>x12/(x13-x14)</td>
</tr>
<tr>
<td>11</td>
<td>LEV2</td>
<td>(x13-x14)/x18</td>
</tr>
<tr>
<td>12</td>
<td>LEV3</td>
<td>x9/x11</td>
</tr>
<tr>
<td>13</td>
<td>LEV4</td>
<td>x9/x6</td>
</tr>
<tr>
<td>14</td>
<td>LEV5</td>
<td>(x6-(x10+x11))/x6</td>
</tr>
<tr>
<td>15</td>
<td>ACT1</td>
<td>x12/x6</td>
</tr>
<tr>
<td>16</td>
<td>ACT2</td>
<td>x12/x8</td>
</tr>
<tr>
<td>17</td>
<td>ACT3</td>
<td>x12/x4</td>
</tr>
<tr>
<td>18</td>
<td>ACT4</td>
<td>x12/x2</td>
</tr>
<tr>
<td>19</td>
<td>ACT5</td>
<td>x12/x3</td>
</tr>
<tr>
<td>20</td>
<td>PFT1</td>
<td>(x18+x14)/x12</td>
</tr>
<tr>
<td>21</td>
<td>PFT2</td>
<td>(x18+x14)/x6</td>
</tr>
<tr>
<td>22</td>
<td>PFT3</td>
<td>x18/x8</td>
</tr>
<tr>
<td>23</td>
<td>PFT4</td>
<td>x58/x24</td>
</tr>
<tr>
<td>24</td>
<td>PFT5</td>
<td>x26/x24</td>
</tr>
<tr>
<td>25</td>
<td>PFT6</td>
<td>(x18+x14)/x8</td>
</tr>
<tr>
<td>26</td>
<td>MNX6</td>
<td>5 year mean of x6</td>
</tr>
<tr>
<td>27</td>
<td>MNLEV4</td>
<td>5 year mean of LEV4</td>
</tr>
<tr>
<td>28</td>
<td>MNACT1</td>
<td>5 year mean of ACT1</td>
</tr>
<tr>
<td>29</td>
<td>MNVAR1</td>
<td>5 year mean of x9/(x10+x11)</td>
</tr>
<tr>
<td>30</td>
<td>CVX6</td>
<td>5 year CV* of x6</td>
</tr>
<tr>
<td>31</td>
<td>COVAR1</td>
<td>5 year CV* of (x13-x14)</td>
</tr>
<tr>
<td>32</td>
<td>CVLIQ3</td>
<td>5 year CV* of LIQ3</td>
</tr>
<tr>
<td>33</td>
<td>CVLIQ6</td>
<td>5 year CV* of LIQ6</td>
</tr>
</tbody>
</table>

*---CV denotes the Coefficient of Variation
**--The number i in xi is the COMPUSTAT item number
***-The definitions of xi are presented in Appendix C
The criterion for variables to enter or leave the model is the significance level of the F test from an analysis of covariance. The significance level used to enter and to stay was .15. An alpha level of .15 insured at least three (or four) variables remained to improve bond ratings prediction.

Yields to maturity for bonds were available for only four (Aaa to Baa) ratings in Moody's Bond Records. The sample firms' bond rating ranged from Aaa to C, but yields were not available for ratings from Ba to C. Rating differences from Ba and C were ignored in the calculation of market value of bonds. However, both four and six classifications were used to select variables which gave better discrimination. The purpose of predicting bond ratings is to estimate the market value of bond for those firms whose ratings were missing. It is, therefore, desirable to find a discriminant model with high discriminating power.

The results of stepwise selection procedures are summarized in Table V. The numbers in Table V corresponds to variable numbers in Table IV. The SAS STEPDISC procedure revealed that size (MNX6) was the most important variable in discriminating bond ratings. From 1968 to 1975, the variable MNX6 was selected first to enter both four and six class models. Since 1976 the importance of MNX6 decreased a little.
<table>
<thead>
<tr>
<th>Year</th>
<th>Four Class Stepwise</th>
<th>Six Class Stepwise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>26, 29, 17, 20, 24</td>
<td>26, 29, 5, 30, 33, 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32, 12, 21, 13</td>
</tr>
<tr>
<td>1969</td>
<td>26, 29, 17, 20, 30</td>
<td>26, 29, 32, 10, 33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13, 7, 6</td>
</tr>
<tr>
<td>1970</td>
<td>26, 29, 6, 33</td>
<td>26, 29, 6, 10, 27, 33</td>
</tr>
<tr>
<td>1971</td>
<td>26, 3, 2, 27</td>
<td>26, 27, 18, 17</td>
</tr>
<tr>
<td>1972</td>
<td>26, 17, 19, 9, 8, 24</td>
<td>26, 17, 19, 24, 4, 28</td>
</tr>
<tr>
<td>1973</td>
<td>26, 9, 21, 28, 23, 18</td>
<td>26, 9, 21</td>
</tr>
<tr>
<td>1974</td>
<td>26, 15, 8, 20</td>
<td>26, 27, 15, 29, 4, 8, 20, 30</td>
</tr>
<tr>
<td>1975</td>
<td>26, 28, 27, 16</td>
<td>26, 15, 5, 29, 27</td>
</tr>
<tr>
<td>1976</td>
<td>8, 26, 28, 16, 3</td>
<td>3, 26, 17, 30, 29, 8</td>
</tr>
<tr>
<td>1977</td>
<td>21, 28, 16, 26</td>
<td>31, 12, 13, 29, 5, 23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27, 10, 17, 8</td>
</tr>
<tr>
<td>1978</td>
<td>17, 21, 24</td>
<td>12, 13, 7, 17, 29, 23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26, 31, 11, 6</td>
</tr>
<tr>
<td>1979</td>
<td>8, 17, 26, 31, 1, 33</td>
<td>12, 29, 13, 10, 23, 26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9, 24, 17, 19</td>
</tr>
<tr>
<td>1980</td>
<td>8, 17, 26, 31, 20, 19</td>
<td>12, 29, 8, 11, 3, 13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27, 7</td>
</tr>
<tr>
<td>1981</td>
<td>19, 17, 10, 32, 15, 18</td>
<td>33, 32, 29, 27, 3, 28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26, 31, 8, 24</td>
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<tr>
<td>1982</td>
<td>9, 17, 3, 10, 26</td>
<td>29, 12, 21, 6, 13, 9, 14, 7</td>
</tr>
</tbody>
</table>
Discriminating power of the models is measured by Wilk's Lambda and Average Squared Canonical Correlation. Wilk's Lambda is the likelihood ratio statistic for testing the hypothesis that the means of the classes on the selected variables are equal in the population. Lambda is close to zero if groups are well separated (30). Average Squared Canonical Correlation is Pillai's trace divided by the number of groups minus one. Pillai's trace is a multivariate statistic which can be used to test whether the means of classes on the selected variables are equal in the population. Average Squared Canonical Correlation is close to one if at least two groups are well separated (30).

Table VI shows the Wilk's Lambda and Average Squared Canonical Correlation for both the four and six class models. The six class STEPDISC procedure generally has more discriminating power than that of the four class procedure. The values of Wilk's Lambda for the four class model are greater than those of six class models in all years except 1973. The values of Average Squared Canonical Correlation for the six class model are greater than those of four class models except for the years of 1970 through 1974. The associated F approximation to both Wilk's Lambda and Average Squared Canonical Correlation were all significant at .01.
### TABLE VI

**DISCRIMINATING POWER OF SAS STEPDISC PROCEDURES**

**FOR BOND RATINGS PREDICTIONS**

<table>
<thead>
<tr>
<th>Year</th>
<th>Four Class Stepwise</th>
<th>Six Class Stepwise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wilk's</td>
<td>ASCC</td>
</tr>
<tr>
<td>1968</td>
<td>0.1022</td>
<td>0.4390</td>
</tr>
<tr>
<td>1969</td>
<td>0.0967</td>
<td>0.4315</td>
</tr>
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<td>1970</td>
<td>0.1300</td>
<td>0.3843</td>
</tr>
<tr>
<td>1971</td>
<td>0.3603</td>
<td>0.2451</td>
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<td>1972</td>
<td>0.2890</td>
<td>0.3036</td>
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<tr>
<td>1973</td>
<td>0.3667</td>
<td>0.2446</td>
</tr>
<tr>
<td>1974</td>
<td>0.4561</td>
<td>0.2081</td>
</tr>
<tr>
<td>1975</td>
<td>0.6945</td>
<td>0.1114</td>
</tr>
<tr>
<td>1976</td>
<td>0.6395</td>
<td>0.1347</td>
</tr>
<tr>
<td>1977</td>
<td>0.7225</td>
<td>0.0999</td>
</tr>
<tr>
<td>1978</td>
<td>0.6401</td>
<td>0.1342</td>
</tr>
<tr>
<td>1979</td>
<td>0.4440</td>
<td>0.2307</td>
</tr>
<tr>
<td>1980</td>
<td>0.3079</td>
<td>0.2896</td>
</tr>
<tr>
<td>1981</td>
<td>0.4756</td>
<td>0.2094</td>
</tr>
<tr>
<td>1982</td>
<td>0.3881</td>
<td>0.2587</td>
</tr>
</tbody>
</table>

Using the variables selected by stepwise discriminant analysis, SAS discriminant analysis was performed for each year from 1968 to 1982. There are three main assumptions upon which discriminant analysis is based: 1) the groups are discrete and known, 2) independent variables are from a multivariate normal distribution, and 3) the variance-covariance matrices are equal across all groups. This study assumes the first two conditions hold. The discriminant function is determined by a measure of generalized squared distance. The discriminant function can be based on either the individual within-group covariance.
matrices or the pooled covariance matrix. If a likelihood ratio test of the homogeneity of the within-group covariance matrices turned out to be significant at .1 level, then within-group covariance matrices were used. Otherwise, a pooled covariance matrix was used to determine the classification criterion.

The results of the test of homogeneity of the within-group covariance matrices are presented in Appendix D. The results of four and six class discriminant analysis are summarized in Table VII.

**TABLE VII**

**EX-POST INTERNAL CLASSIFICATION RATES OF BOND RATING MULTIPLE DISCRIMINANT ANALYSES**

<table>
<thead>
<tr>
<th>Year</th>
<th>Four Class Model</th>
<th></th>
<th></th>
<th>Six Class Model</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correctly</td>
<td>N</td>
<td>Percent</td>
<td>Correctly</td>
<td>N</td>
<td>Percent</td>
</tr>
<tr>
<td></td>
<td>Classified</td>
<td></td>
<td></td>
<td>Classified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td>42</td>
<td>49</td>
<td>.86 *</td>
<td>41</td>
<td>48</td>
<td>.85</td>
</tr>
<tr>
<td>1969</td>
<td>52</td>
<td>57</td>
<td>.91 *</td>
<td>46</td>
<td>57</td>
<td>.81</td>
</tr>
<tr>
<td>1970</td>
<td>51</td>
<td>67</td>
<td>.76 *</td>
<td>46</td>
<td>67</td>
<td>.69</td>
</tr>
<tr>
<td>1971</td>
<td>55</td>
<td>77</td>
<td>.71</td>
<td>65</td>
<td>77</td>
<td>.84 *</td>
</tr>
<tr>
<td>1972</td>
<td>68</td>
<td>84</td>
<td>.81 *</td>
<td>66</td>
<td>84</td>
<td>.79</td>
</tr>
<tr>
<td>1973</td>
<td>73</td>
<td>100</td>
<td>.73 *</td>
<td>71</td>
<td>100</td>
<td>.71</td>
</tr>
<tr>
<td>1974</td>
<td>82</td>
<td>106</td>
<td>.77</td>
<td>88</td>
<td>106</td>
<td>.83 *</td>
</tr>
<tr>
<td>1975</td>
<td>80</td>
<td>122</td>
<td>.66 *</td>
<td>67</td>
<td>122</td>
<td>.55</td>
</tr>
<tr>
<td>1976</td>
<td>77</td>
<td>119</td>
<td>.65</td>
<td>83</td>
<td>119</td>
<td>.70 *</td>
</tr>
<tr>
<td>1977</td>
<td>83</td>
<td>117</td>
<td>.71</td>
<td>95</td>
<td>116</td>
<td>.82 *</td>
</tr>
<tr>
<td>1978</td>
<td>74</td>
<td>99</td>
<td>.75</td>
<td>75</td>
<td>98</td>
<td>.77 *</td>
</tr>
<tr>
<td>1979</td>
<td>46</td>
<td>84</td>
<td>.55</td>
<td>67</td>
<td>84</td>
<td>.80 *</td>
</tr>
<tr>
<td>1980</td>
<td>65</td>
<td>83</td>
<td>.78</td>
<td>68</td>
<td>84</td>
<td>.81 *</td>
</tr>
<tr>
<td>1981</td>
<td>53</td>
<td>74</td>
<td>.72</td>
<td>61</td>
<td>75</td>
<td>.81 *</td>
</tr>
<tr>
<td>1982</td>
<td>47</td>
<td>70</td>
<td>.67</td>
<td>58</td>
<td>69</td>
<td>.84 *</td>
</tr>
</tbody>
</table>

*--Highest classification rates; used in predicting missing ratings
Each discriminant analysis used sample proportions as its prior probabilities. For all discriminant analyses, the ex-post internal classification rates were calculated. The ex-post internal classification rate is the percentage of correctly classified bond ratings when the derived discriminant function based on one data is applied to the same data (25). When the six class model was used, an internal classification ratio was calculated after assigning Ba class to every original and predicted ratings of Ba through C. The differences in sample size, N, between the four and six class discriminant analyses were caused by the missing data on the discriminating variables.

Using the calibration information derived from the above discriminant analyses, sample firms' missing bond ratings were predicted. For predicting bond ratings, the discriminant model which gives highest internal classification results was employed.

Prediction of some bond ratings was not possible in some cases due to missing information on the discriminating variables. For these firms past ratings were used. An average of the past five bond ratings was used as proxy of the firm's bond rating for a particular year.

Yields to maturity corresponding to the ratings for the sample period of 1968 - 1982 were obtained from Moody's corporate bond yield averages. As the yield for a
particular year, yield for the month of December was used. Market values of bonds were calculated according to the formula described in equation (3-4) in Chapter III.

**Estimation of Replacement Cost for Net Plant**

Parker's algorithm (24) was employed to estimate a replacement value for net plant and equipment. Parker's method was originally used to adjust for changes in net plant value caused by general price level changes. This algorithm was also used in Hasbrouck's study (13). First, the average age of a firm's plant on hand at year end is obtained by dividing the accumulated depreciation with the depreciation expenses for a particular year. Accumulated depreciation was estimated by subtracting net plant (COMPUSTAT item number 8) from gross plant (COMPUSTAT item number 7).

Let $h$ denote the average age of firm's asset, then the replacement value of net plant at time $t$, $RNP_t$, is calculated as follows:

$$RNP_t = HNP_t \times \frac{(\text{GNP Deflator index at time } t)}{(\text{GNP Deflator index at time } t-h)} \quad (4-1)$$

Replacement value for net plant is estimated by restating the reported net plant using the GNP Deflator Index of the acquisition date (current year - average age of assets). GNP Deflator Indexes are available from National Income
Accounts. Quarterly indexes were used to approximate the GNP Deflator Index at time $t - h$. For example, if $t - h$ is 67.4 then the second quarter of year 1967 GNP Deflator Index was used.

The calculated average age of sample firms' assets is summarized in Table VIII. Average ages for targets and control are a little lower than those of acquirer and control.

**TABLE VIII**

**AVERAGE AGE OF PLANT**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Average Age of Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Targets</td>
<td>7.509 years</td>
</tr>
<tr>
<td>Acquirers</td>
<td>6.837</td>
</tr>
<tr>
<td>Target Control</td>
<td>7.517</td>
</tr>
<tr>
<td>Acquirer Control</td>
<td>7.196</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7.181</strong></td>
</tr>
</tbody>
</table>

The implicit assumptions of Parker's algorithm are, first, that all sample firms use straight-line depreciation, and second, there have been no significant changes in technology. Thus, the estimated average age and derived replacement value for net plant might be overestimated if some firms used accelerated depreciation. Depreciation methods are not included in COMPUSTAT data; this could not be checked. If there has been considerable technological progress, Parker's algorithm underestimates replacement values for the net plant.
Estimation of Replacement Cost for Inventories

Lindenberg and Ross's method was used to estimate replacement values for inventory, except when firms use LIFO inventory valuation. Lindenberg and Ross's adjustment scheme for LIFO requires that replacement value for inventory at time \( t - 1 \) be known \textit{a priori} to estimate the replacement value at time \( t \). Lindenberg and Ross's adjustment equation is as follows (18, p. 15):

\[
RINV_t = RINV_{t-1} \left( \frac{1}{2} \right) + \frac{1}{2} (HINV_t - HINV_{t-1}) \left( \frac{p_t + p_{t-1}}{p_{t-1}} \right) \quad (4-2)
\]

Even though a recursive relationship can be used to obtain \( RINV_{t-1} \), \( RINV_{t-2} \) is still needed to estimate \( RINV_{t-1} \) unless an arbitrary starting value is assumed. Lindenberg and Ross are unclear on this matter. Parker's algorithm was used to estimate inventory replacement cost for those firms that employed LIFO.

Table IX summarizes the sample firms' inventory valuation methods. When firms reported several inventory valuation methods, the most frequently used method was regarded as its only method. COMPSTAT specifies seven different methods of inventory valuation. They are LIFO, FIFO, the Average Cost Method, the Retail Cost Method, the Standard Cost Method, Current or Replacement Cost Method, and Specific Identification. The first three are most frequently used.
TABLE IX

SAMPLE FIRMS' INVENTORY VALUATION METHODS

<table>
<thead>
<tr>
<th>Groups</th>
<th>LIFO</th>
<th>FIFO</th>
<th>Average</th>
<th>standard</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Acquirer Target Control</td>
<td>18</td>
<td>19</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>12</td>
<td>15</td>
<td>3</td>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td>Target Acquirer Control</td>
<td>14</td>
<td>23</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>10</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>64</td>
<td>37</td>
<td>9</td>
<td>5</td>
<td>180</td>
</tr>
</tbody>
</table>

Lindenberg and Ross's adjustment equations for two inventory valuation methods are as follows:

1) FIFO
   \[ RINV_t = HINV_t \]  \hspace{1cm} (4-3)  

2) Average Cost Method
   \[ RINV_t = HINV_t \frac{2P}{\left(\frac{P_{t-1}}{P_t}\right)} \] \hspace{1cm} (4-4) 

where \( P \) is an appropriate price index. As a measure of \( P_t \), GNP Deflator indexes were used. In FIFO, remaining inventories are priced at the most recent prices. Thus, as long as the remaining inventories were purchased relatively recently, the approximation \( RINV_t = HINV_t \) seems reasonable. Average cost method values inventory at roughly an average of \( P_{t-1} \) and \( P_t \). Lindenberg and Ross's adjustment scheme for average cost is reasonable when inventories have been evenly accumulated over the prior periods.
Parker's method (24) was used to estimate replacement values for firms inventory valued by LIFO. As a first step, Parker's algorithm tries to break down the historical inventory value at time $t$, $\text{HINV}_t$, into its originally acquired date $t$, $t-1$, $t-2$, etc. That is, $\text{HINV}_t$ is a sum of $\text{hinv}_{j}$ where $\text{hinv}_{j}$ is the value of inventory which is acquired at year $j$. To estimate $\text{hinv}_{j}$, Parker assumes an arbitrary starting point $t_0$. The year 1970 = $t_0$ in this study. The steps necessary to estimate $\text{hinv}_{j}$ are as follows. 1) Year to year changes in inventories, $\text{CINV}_{j}$, were calculated as

$$
\text{CINV}_{t_0} = \text{HINV}_{t_0} \quad \text{if } j = t_0 \\
\text{CINV}_{j} = \text{HINV}_{j} - \text{HINV}_{j-1} \quad \text{if } t_0 < j \leq t 
$$

(4-5)

The change in inventory at time $t_0$ is assumed to be equal to the historical inventory value at time $t_0$. For the other periods, the changes in inventories are the difference between the value of historical inventory ($\text{HINV}_{j}$) and the historical inventory value of previous year. 2) If $\text{CINV}_{j}$ for all $j$, $t_0 < j \leq t$, has positive value, then $\text{hinv}_{j} = \text{CINV}_{j}$. If there is more than one negative change ($\text{CINV}_{j}$) another adjustment is needed to estimate the annual $\text{hinv}_{j}$. Negative $\text{CINV}_{j}$ means inventories consumed at year $j$ were more than the amount of inventory acquired during the $j$th year. In LIFO, the decrease in inventory come from the consumption of the most recently added inventories. Thus,
when $CINV_j$ is negative, the changes in inventory value of most recent period, $CINV_{j-1}$, need to be corrected by the value of $CINV_j$.

When there is only one negative value, for example if $CINV_1$ was negative, then $CINV_{i-1}$ was adjusted to get $AICINV_{i-1}$, sum of $CINV_{i-1}$ and $CINV_i$. $AICINV_1$ is set to zero. If the $AICINV$ is positive, then $AICINV_{i-1} = AICINV_i$ and $hinv = 0$ and $AICINV_j$ for $j \neq i$ or $j \neq i-1$ is equal to $CINV_j$, which is equal to $AICINV_j$.

The $i$ in $AICINV$ denotes the number of times $CINV$ has been adjusted. If $AICINV_{i-1}$ is still negative, then the above process continues until all negative $CINV$ are eliminated. When there are more than two negative $CINV$s, the process starts from the most recent year to $t$. By starting from $t$, the number of iterations to obtain all positive $CINV_j$ is reduced. If $AICINV_j$ is negative then $A2CINV_{j-1}$ was adjusted to

$$A2CINV_{j-1} = AICINV_j + AICINV_{j-1}$$

$$A2CINV_j = 0 \quad \text{if } AICINV < 0 \quad (4-6)$$

3) The value $AICINV_j$, which completely satisfies step 2) above, was used as the estimate of $hinv_j$.

The replacement value estimate for inventory, $RINV_j$, was obtained by adjusting $hinv$, i.e.,
By summing up inflation adjusted \( h_{in\text{v}_j} \), the estimate of replacement value for inventory was calculated. Parker’s method implicitly assumes the inventory purchases for any given year are evenly distributed throughout that year.

Table X illustrates the Parker’s algorithm using hypothetical data.

**TABLE X**

**EXAMPLE OF PARKER’S ALGORITHM USING HYPOTHETICAL DATA**

<table>
<thead>
<tr>
<th>Year</th>
<th>Historical Inventory HINV(i)</th>
<th>Changes in HINV(i) CINV(i)</th>
<th>A1CINV(i)</th>
<th>A2CINV(i)</th>
<th>hinv(i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>7800</td>
<td>7800</td>
<td>7800</td>
<td>7800</td>
<td>7800</td>
</tr>
<tr>
<td>1973</td>
<td>8200</td>
<td>400</td>
<td>400</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>1974</td>
<td>8100</td>
<td>-100</td>
<td>-200</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1975</td>
<td>8000</td>
<td>-100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1976</td>
<td>8700</td>
<td>700</td>
<td>700</td>
<td>700</td>
<td>700</td>
</tr>
<tr>
<td>1977</td>
<td>9500</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>1978</td>
<td>10000</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>

Two negative CINVs, CINV(1974) and CINV(1975), result from step 1 in the hypothetical example. By applying step 2, A1CINV(1975) is set to zero, CINV(1974) is adjusted to -200 (A1CINV(1974)) and all other A1CINV(i) except 1974 and 1975 are set to CINV(i). Since there still is a negative A1CINV(i), another iteration of step 2 is followed to get
1975 are set to $CINV(i)$. Since there still is a negative $A1CINV(i)$, another iteration of step 2 is followed to get all non-negative values of $A2CINV(i)$. These non-negative $A2CINV(i)$'s are estimates of $hinv(i)$.

**Summary of Sample Firms**

Originally seventy-one firms were included in each of the four sample groups, acquiring and acquired firms and their matched control firms. When another restriction on the size of a firm was applied, at least 100 million of total assets at merging year, eleven sample firms were lost. Consequently there were sixty firms in each group. Of these sixty, eight acquiring firms merged more than once. Only one merger for each acquiring firm was included in the sample. The number of firms in each group was reduced to fifty-two by deleting the multiple-merger firms. One firm was deleted from the sample because of missing information on the preferred dividends. Four firms were deleted because of missing data needed to calculate replacement value estimates. Two mergers announcements were pre-1976.

The final sample consists of forty-five firms in each of four sample groups. Only forty-five firms were included in the paired-comparison t-test. However, other parts of the analyses included more—as many as possible in each case. For example, all the available bond ratings were included in the bond rating prediction models. Table XI shows the industry distribution of the sample firms.
TABLE XI

The Industry Distribution of Sample Firms

<table>
<thead>
<tr>
<th>Industry Code</th>
<th>Target</th>
<th>Acquirer</th>
<th>Target Control</th>
<th>Acquirer Control</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000-1499 a</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>1500-1999 b</td>
<td>.</td>
<td>1</td>
<td>.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2000-2499 c</td>
<td>9</td>
<td>10</td>
<td>9</td>
<td>11</td>
<td>39</td>
</tr>
<tr>
<td>2500-2999 d</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>10</td>
<td>46</td>
</tr>
<tr>
<td>3000-3499 e</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>3500-3999 f</td>
<td>17</td>
<td>13</td>
<td>16</td>
<td>14</td>
<td>60</td>
</tr>
<tr>
<td>4000 g</td>
<td>.</td>
<td>4</td>
<td>.</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>180</td>
</tr>
</tbody>
</table>

- a-Mining Industry
- b-Construction Industry
- c-Food, Tobacco, Textile, Apparel, and Lumber
- d-Furniture, Paper, Printing, Chemical, and Petroleum
- e-Rubber, Leather, Stone, and Metal Products
- f-Electric, Electronic, and Transportation Equipment
- g-Transportation and Public Utilities or Wholesale

One hundred and sixty-two firms out of 180 total sample firms are manufacturing firms (SIC Industry Code from 2000 to 3999). Only eight firms were from the mining industry (SIC Industry Code from 1000 to 1499). Only mining and manufacturing target firms were to be included in this study. Matched acquiring firms were all included regardless of their industry codes. Control sample firms were matched by size and industry. The yearly distribution of the forty-five sample mergers were six, thirteen, ten, two, eight, four, and two, for the seven years 1976 through 1982, respectively.
The Adjustment of Tobin's q

Using the previously described procedures, Tobin's q's were calculated for each sample firm. Table XII shows yearly-average and merger announcement year average q's for different groups. Yearly-average q of all sample firms is also presented.

TABLE XII

MEAN VALUES OF TOBIN's q (EQUALLY WEIGHTED)

<table>
<thead>
<tr>
<th>Year</th>
<th>Targets $q_t^1$</th>
<th>Acquirer $q_t^2$</th>
<th>Target Control $q_t^3$</th>
<th>Acquirer Control $q_t^4$</th>
<th>Total $q_t^m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>0.7997</td>
<td>0.9982</td>
<td>0.8186</td>
<td>0.9194</td>
<td>0.8840</td>
</tr>
<tr>
<td>1977</td>
<td>0.7715</td>
<td>0.9202</td>
<td>0.7632</td>
<td>0.7997</td>
<td>0.8151</td>
</tr>
<tr>
<td>1978</td>
<td>0.7659</td>
<td>0.8826</td>
<td>0.7289</td>
<td>0.7405</td>
<td>0.7814</td>
</tr>
<tr>
<td>1979</td>
<td>0.8074</td>
<td>0.9225</td>
<td>0.7714</td>
<td>0.7306</td>
<td>0.8081</td>
</tr>
<tr>
<td>1980</td>
<td>0.7702</td>
<td>1.0189</td>
<td>0.7899</td>
<td>0.7366</td>
<td>0.8411</td>
</tr>
<tr>
<td>1981</td>
<td>0.8108</td>
<td>0.8496</td>
<td>0.7216</td>
<td>0.6926</td>
<td>0.7570</td>
</tr>
<tr>
<td>1982</td>
<td>0.4610</td>
<td>0.8490</td>
<td>0.8238</td>
<td>0.7600</td>
<td>0.8054</td>
</tr>
<tr>
<td>Merger</td>
<td>0.8081</td>
<td>0.9884</td>
<td>0.8011</td>
<td>0.7730</td>
<td>0.8427</td>
</tr>
</tbody>
</table>

To adjust q for the differences in the responsiveness of $q^1$ to market trend, $q_t^m$ and $q_t^1$, $q_t^2$, $q_t^3$ and $q_t^4$ were calculated, where $q_t^m$ is the proxy of Tobin's q for the market at time t, and $q_t^1$, $q_t^2$, $q_t^3$ and $q_t^4$ are the averages of Tobin's q for four sample groups. Table XII includes the average of Tobin's q when each of q-value is given equal weight in the average. The average Tobin's q at the year of merger announcement for targets and control were almost the
same, while there is a .215 difference between acquirer and control.

Another set of average Tobin's q-values was calculated using firms' market value as weights. The market values used as weights were the same ones used to calculate q-values. The results are summarized in Table XIII.

**TABLE XIII**

**MEAN VALUES OF TOBIN's q (MARKET VALUE WEIGHTED)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Targets</th>
<th>Acquirer</th>
<th>Target Control</th>
<th>Acquirer Control</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>((\bar{q}_t^1))</td>
<td>((\bar{q}_t^2))</td>
<td>((\bar{q}_t^1))</td>
<td>((\bar{q}_t^2))</td>
<td>((\bar{q}_t^m))</td>
</tr>
<tr>
<td>1976</td>
<td>0.8256</td>
<td>0.8939</td>
<td>1.0039</td>
<td>0.8567</td>
<td>0.8855</td>
</tr>
<tr>
<td>1977</td>
<td>0.7447</td>
<td>0.8206</td>
<td>0.8163</td>
<td>0.7451</td>
<td>0.7882</td>
</tr>
<tr>
<td>1978</td>
<td>0.7154</td>
<td>0.8250</td>
<td>0.7764</td>
<td>0.6890</td>
<td>0.7672</td>
</tr>
<tr>
<td>1979</td>
<td>0.7875</td>
<td>0.8885</td>
<td>0.8596</td>
<td>0.6669</td>
<td>0.8081</td>
</tr>
<tr>
<td>1980</td>
<td>0.8254</td>
<td>1.1443</td>
<td>0.9323</td>
<td>0.6902</td>
<td>0.9729</td>
</tr>
<tr>
<td>1981</td>
<td>1.0131</td>
<td>0.8214</td>
<td>0.7612</td>
<td>0.6663</td>
<td>0.7714</td>
</tr>
<tr>
<td>1982</td>
<td>0.4935</td>
<td>0.7529</td>
<td>0.9091</td>
<td>0.7369</td>
<td>0.7603</td>
</tr>
<tr>
<td>merger</td>
<td>0.8270</td>
<td>0.9098</td>
<td>0.8661</td>
<td>0.7193</td>
<td>0.8370</td>
</tr>
</tbody>
</table>

When market weights are used, the \(\bar{q}_t^2\) and \(\bar{q}_t^m\) are smaller than those calculated using equal weights. This implies that there may be relatively large size firms which have smaller q's. The exception is \(\bar{q}_t^1\), which when weighted equally are larger than those of market-value weighted without exception. The value \(\bar{q}_t^1\) displays no evident patterns, which could mean evenly distributed firm sizes.
The following adjustment regressions for each of four sample groups described in Equation (3-15) were run using the individual and average q-values calculated above:

\[ q_{t,j}^i = a^i + b^i(q_m^i - q_t^i) + e_{t,j}^i, \quad j=1, \ldots, n \]  

(3-15)

where \( q_{t,j}^i \) is the q-value of firm j in sample group i at year t, and t denotes the merger announcement year. For each of the four groups, the above regressions were run using both market-weighted and equally-weighted averages. As a result, eight adjustment regressions were run using merger announcement year data. The coefficients estimated are presented in Table XIV under the heading of MERGER. The coefficients estimated using equally-weighted average q-values are presented under the name of EQ. MV indicates the adjustment regressions with market-weighted average q-values.

Originally, the adjustment regressions were planned to include q-values of only merger announcement year, to capture the differences in the responsiveness to the market trend between experimental and control groups around the merger announcement period, if any. Another set of regressions which includes all the available q-values was run to check whether responsiveness at the time of merger announcement was different from the general responsiveness. Thus, another eight regressions were run using all available q-values. The results are given in the section ALL YEAR.
**TABLE XIV**

REGRESSION COEFFICIENT OF ADJUSTMENT EQUATIONS

<table>
<thead>
<tr>
<th>Data Used</th>
<th>Constant (t value)</th>
<th>Slope (t value)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MERGER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Targets</td>
<td>0.855 (15.44) **</td>
</tr>
<tr>
<td>V</td>
<td>Acquirer</td>
<td>.933 ( 7.86) **</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>.769 (12.62) **</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>.796 (10.58) **</td>
</tr>
<tr>
<td><strong>YEAR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E Q Target</td>
<td>Targets</td>
<td>.879 (14.46) **</td>
</tr>
<tr>
<td></td>
<td>Acquirer</td>
<td>.918 ( 3.14) **</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>.884 ( 5.05) **</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>.802 (11.89) **</td>
</tr>
<tr>
<td><strong>ALL YEAR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M V Target</td>
<td>Targets</td>
<td>.794 (26.49) **</td>
</tr>
<tr>
<td></td>
<td>Acquirer</td>
<td>.887 (21.53) **</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>.756 (33.17) **</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>.807 (21.99) **</td>
</tr>
<tr>
<td><strong>YEAR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E Q Target</td>
<td>Targets</td>
<td>.805 (23.21) **</td>
</tr>
<tr>
<td></td>
<td>Acquirer</td>
<td>.768 ( 8.65) **</td>
</tr>
<tr>
<td></td>
<td>Target</td>
<td>.792 (22.08) **</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>.832 (24.43) **</td>
</tr>
</tbody>
</table>

*-- Significant at .05
**-- Significant at .01
a-- MV denote adjustment regression with market value weighted q's
b-- EQ denote adjustment regression with equally weighted q
c-- merger denote adjustment regression with only merger announcement year q values
d-- ALL YEAR denotes adjustment regression with all q available
The intercepts which can be viewed as long run values of q's for four different groups were all significant at the .01 level without exception, regardless of which adjustment regression was used.

Among the four groups, acquirer has the highest constant except when all year data and equally-weighted case. One thing to note is that the constants of both targets and acquirers for merger announcement year data are higher than those for all year data. This indicates that mergers generally occur when both acquirers and targets have higher q-values than usual, i.e., when they have exceptionally high incentives to invest.

The slope coefficients were all negative in all adjustment equations. There do not seem to be marked differences in the responsiveness to the market changes among the four groups. Most of the slope coefficients were insignificant at the .05 level. The null hypothesis of \( b=0 \) cannot be rejected in the majority of the regressions. When the above four different types of adjustment regressions were run using the log-transformed values of Tobin's q, the results were also not significant. However, the adjustment for the differences in the responsiveness to the market trend was done to see how the adjusted values of q perform in the test of normality.
Test of Hypotheses

A paired comparison t-test was employed to test the hypotheses that merging firms' q values are significantly different from their control group of firms. The reason the paired comparison t-test was used is that q values in experimental groups would be correlated with the values of control firms. If this is a correct judgement, the paired q-values would not be independent variables but instead correlated, or non-independent variables (10, p. 216);

Let \((q_1, q_2)\) be the paired values and let \(D\) be the difference of two paired values, \(D = q_1 - q_2\), then the variance of the differences \(D\), \(S_D^2\) is

\[
S_D^2 = S_{q_1}^2 + S_{q_2}^2 - 2r_{q_1q_2} S_{q_1} S_{q_2}
\]

(4-8)

The variance of \(\bar{D}\) will be 1/nth the variance of \(D\) where \(n\) is the number of paired values. Thus, \(S_{\bar{D}}^2\), the variance of the differences between two paired mean values is calculated as follows;

\[
S_{\bar{D}}^2 = S_{\bar{q}_1}^2 + S_{\bar{q}_2}^2 - 2r_{q_1q_2} S_{\bar{q}_1} S_{\bar{q}_2}
\]

(4-9)

which equals the value \(\{\Sigma (D-\bar{D})^2 / n(n-1)\}\), where \(r_{q_1q_2}\) is the correlation coefficient between \(q_1\) and \(q_2\) . If \(q_1\) and \(q_2\) are independent their correlation coefficient is zero. If \(r_{q_1q_2}\) is positive, then the standard error of the difference
between two means will be reduced—depending upon the degree of correlation. Reducing the standard error increases the t-value which in turn increases the probability of rejecting the null hypothesis. The most important assumption of the t-test is normality; normality of q-values was examined first.

Test of Normality

To check whether the observed differences in q values between experimental and control firms come from a normal distribution, Pearson's Chi-Square test could be applied. However, with continuous variables there is a loss of information if the Chi-Square test is used because the Chi-Square test utilizes only the number of observations in intervals rather than the observation themselves. A Shapiro-Wilk's statistic was used instead.

The basic idea of the Shapiro-Wilk statistic (3) is that if the empirical distribution in question is close to a normal distribution, then the normal probability plot tends to fall near the straight line. If the empirical distribution is not close to a normal, then the plot should look non-linear. Let q(1), . . . q(i) . . . , q(n) be an order statistic where i is the rank of variable q, then normal probability plot is a set of points of \( \{q(i), \Phi^{-1}(\hat{F}_n(q(i)))\} \) where \( \Phi^{-1} \) is the inverse of normal distribution function and \( \hat{F} \) is empirical distribution function. \( F \) is
estimated by \( \frac{i}{n} \) or \( \frac{(i-1/2)}{n} \) where \( n \) is the number of sample points.

Thus, the squared correlation of points will be close to one if the tested distribution is indeed normal. The Shapiro-Wilk statistic, \( W \), is similar to the squared correlation but more complicated. The statistic \( W \) is also close to one if the empirical distribution is close to normal. The critical values are given in Shapiro and Wilk (32). SAS PROC UNIVARIATE procedure (29) calculates the value of the Shapiro-Wilk's statistic.

In a paired comparison t-test, differences between two variables are treated as a variable. A test of normality was performed to the matched differences of \( q \) between experimental and control firms. Table XV presents the values of the Shapiro-Wilk Statistic.

The variable \( D_q \) denotes the difference of \( q \) between experimental and control firms. \( D_{lnq} \) is the difference of log transformed \( q \) between two groups. \( D_{qade} \) is the difference of adjusted \( q \) using equal weights. Likewise, \( D_{qadm} \) is the difference of adjusted \( q \) using market value weights. \( D_{qadeln} \) is the difference of log-transformed adjusted \( q \) with equal weights. \( D_{qadmln} \) is the difference of log-transformed adjusted \( q \) with market weights. As in Table XIV, merger year means when \( q \) values of only merger announcement year were used in the adjustment regressions.
TABLE XV
RESULTS OF NORMALITY TESTS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Merger Year</th>
<th>All Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target-</td>
<td>Acquirer-</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>-Control</td>
</tr>
<tr>
<td>Dq</td>
<td>0.927 *</td>
<td>0.897**</td>
</tr>
<tr>
<td>Dlnq</td>
<td>0.944 *</td>
<td>0.963</td>
</tr>
<tr>
<td>Dqade</td>
<td>0.903**</td>
<td>0.895**</td>
</tr>
<tr>
<td>Dqadln</td>
<td>0.948</td>
<td>0.969</td>
</tr>
<tr>
<td>Dqadm</td>
<td>0.915**</td>
<td>0.897**</td>
</tr>
<tr>
<td>Dqadmln</td>
<td>0.945</td>
<td>0.973</td>
</tr>
</tbody>
</table>

* significant at .05
** significant at .01
all others not significant at .05

The Dq's for groups (targets-control) and (acquirer-control) had significant Shapiro-Wilk statistics at the .01 level, implying that the distribution of Dq is significantly different from a normal distribution. Both Dqade and Dqadm were also significantly different from a normal distribution at the .01 level. However, the differences of log-transformed q values, Dlnq, Dqadln and Dqadmln have insignificant Shapiro-Wilk statistics at .05 (except Dlnq of targets-control). Even Dlnq of group (target-control) was insignificant at the .01 level.

The log-transformed q-values Dlnq, Dqadln and Dqadmln were not significantly different from a normal distribution, while nominal variables Dq, Dqade and Dqadm were significantly different from a normal. Consequently, the
emphasis of the paired comparison test is on the log-transformed q-values, Dlnq, Dqadeln and Dqadmin. Note that the two variables, Dqadeln and Dqadmln are log transformed values of adjusted q, but the slope coefficients of adjustment regressions were not significantly different from zero. The variable Dlnq, difference of log-transformed unadjusted q-values, which satisfies test of normality, seems the most appropriate variable to be used in the paired comparison t-test.

**Test of Hypotheses**

Hypothesis II, that says that the q-value of target on average should be smaller than that of control firms in an allocationally efficient market, was tested by the paired comparison test. The t-values are presented in Table XVI.

**TABLE XVI**

RESULTS OF PAIRED COMPARISON T-TEST FOR TARGET AND CONTROL

<table>
<thead>
<tr>
<th>Variable</th>
<th>t Value</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Merger Year</td>
<td>All Year</td>
<td></td>
</tr>
<tr>
<td>Dq</td>
<td>0.10</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Dlnq</td>
<td>0.09</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Dqade</td>
<td>-0.07</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Dqadeln</td>
<td>-0.05</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Dqadm</td>
<td>1.25</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Dqadmln</td>
<td>1.72 *</td>
<td>0.61</td>
<td></td>
</tr>
</tbody>
</table>

* significant at .1
The values of \( t \) were all insignificant at the 0.05 level, which implies that there are no significant differences in Tobin's \( q \) between target firms and the related control firms. In one instance, \( Dqadmln \), the \( t \)-value was significant at the .1 level. The results provide insufficient evidence to support the hypothesis that the average \( q \)-value of the target group was lower than that of the control firm. To the contrary, the average value of Tobin's \( q \) for targets seems to be higher than that of control firms, although statistically not significant.

Table XVII shows the \( t \)-values of paired comparison tests for acquirer versus control. Although many of \( t \) values measured are not significant at 0.05, \( Dq \) and \( Dlnq \) (the difference between \( q \) and log-transformed \( q \)-values for acquirer and their control) have significant \( t \) values.

**TABLE XVII**

RESULTS OF PAIRED COMPARISON T-TEST FOR ACQUIRER AND CONTROL

<table>
<thead>
<tr>
<th>Variable</th>
<th>( t ) Value Merger Year</th>
<th>( t ) Value All Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Dq )</td>
<td>2.58 **</td>
<td>2.58 **</td>
</tr>
<tr>
<td>( Dlnq )</td>
<td>2.81 ***</td>
<td>2.81 ***</td>
</tr>
<tr>
<td>( Dqade )</td>
<td>1.40</td>
<td>-0.04</td>
</tr>
<tr>
<td>( Dqadeln )</td>
<td>1.01</td>
<td>-1.16</td>
</tr>
<tr>
<td>( Dqadm )</td>
<td>1.66</td>
<td>1.69 *</td>
</tr>
<tr>
<td>( Dqadmln )</td>
<td>1.37</td>
<td>1.44</td>
</tr>
</tbody>
</table>

* denote significant at .1 level
** denote significant at .05 level
*** denote significant at the .01 level
The variables Dqade, Dqadm, Dqadeln, and Dqadmln do not have significant t-values. However, the variable Dlnq, which satisfied the condition of normality and did not adjust q-values using insignificant slopes, has the most significant t-value. The fact that Dlnq has a significant positive t-value means acquirers' q-value, on average, is significantly higher than that of control firms. This result is consistent with the proposed Hypothesis I that acquiring firms should have higher q-values than those of control firms if markets are allocationally efficient.

Prediction of Takeovers

Probit analyses were done to see whether the behaviors of merging firms are predictable using the value of Tobin's q and other adjusted q's. Since the log-transformed values of q, lnq, for acquirers were found to have a significantly higher mean than that of the controls, lnq was used first as an independent variable. The dependent variable is one if a firm is an acquirer and zero if a firm is not an acquirer. For each of seven sample years from 1976 to 1982, separate probit coefficients were estimated by the maximum likelihood method of SHAZAM VERSION 5.1. One more probit estimation was done using only merger announcement year data.

The results of probit estimation are summarized in Table XVIII. SHAZAM calculates several statistics together with the maximum likelihood estimators, only part of which are presented in the Table XVIII.
TABLE XVIII

SUMMARY STATISTICS OF PROBIT ANALYSIS (lnq)

<table>
<thead>
<tr>
<th>Year</th>
<th>Constant (1)</th>
<th>Slope (2)</th>
<th>t Value (3)</th>
<th>L-R (4)</th>
<th>C-U R^2 (5)</th>
<th>No(N)^a</th>
<th>No(n)^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>-1.796</td>
<td>0.228</td>
<td>0.4635</td>
<td>0.211</td>
<td>0.005</td>
<td>174(180)</td>
<td>0(6)</td>
</tr>
<tr>
<td>1977</td>
<td>-1.371</td>
<td>0.289</td>
<td>0.7203</td>
<td>0.513</td>
<td>0.007</td>
<td>161(174)</td>
<td>0(13)</td>
</tr>
<tr>
<td>1978</td>
<td>-1.399</td>
<td>0.509</td>
<td>1.2168</td>
<td>1.476</td>
<td>0.025</td>
<td>150(160)</td>
<td>0(10)</td>
</tr>
<tr>
<td>1979</td>
<td>-2.100</td>
<td>0.954</td>
<td>1.4071</td>
<td>1.957</td>
<td>0.098</td>
<td>149(151)</td>
<td>0(2)</td>
</tr>
<tr>
<td>1980</td>
<td>-1.503</td>
<td>0.536</td>
<td>1.5574</td>
<td>2.368</td>
<td>0.046</td>
<td>141(149)</td>
<td>0(8)</td>
</tr>
<tr>
<td>1981</td>
<td>-1.768</td>
<td>0.469</td>
<td>1.1051</td>
<td>1.197</td>
<td>0.037</td>
<td>137(141)</td>
<td>0(4)</td>
</tr>
<tr>
<td>1982</td>
<td>-2.057</td>
<td>0.857</td>
<td>1.4811</td>
<td>2.223</td>
<td>0.115</td>
<td>128(130)</td>
<td>0(2)</td>
</tr>
<tr>
<td>merge</td>
<td>-0.525</td>
<td>0.659</td>
<td>2.6030*</td>
<td>6.96*</td>
<td>0.056</td>
<td>138(180)</td>
<td>3(45)</td>
</tr>
</tbody>
</table>

*--significant at 0.01
a--N is the number of total observation
b--n is the number of acquirers included

Maximum likelihood estimators of constant and slope are shown in the first and second columns. The third column shows the asymptotic t values of slopes. The likelihood ratio statistic and Cragg-Uhler R^2 (19, p. 40), as a measure of goodness of fit, are presented in the fourth and fifth columns. Column six presents the number of correct predictions out of the total observations. The last column provides the number of right predictions for acquirers out of total acquirers included in the analysis.

The positive slopes mean higher lnq's are associated with acquirers, but the significance of slope coefficients indicated by the asymptotic t-values are low except when only merger announcement year data are included. The significant t-value when only merger announcement year data
are included in the probit analysis indicates that there is a difference in q-values of acquirers and non-acquirers around the merger announcement period.

The intercepts are negative and have high t-values, implying that lnq does not give high explanatory power for acquirers' behavior. Negative intercepts result from most of the q-values being less than one.

The likelihood ratio statistic, $-2\ln(\hat{L}_\omega / L_0)$, which is known to converge to a chi-square distribution with degree of freedom one (35, p. 397) where $\hat{L}_\omega$ is the maximum of likelihood function with respect to only constant and $L_0$ is the maximum of likelihood function with respect to all parameters, was also very low. Cragg-Uhler $R^2$, which can have a maximum value of one, was also very low. Overall, the independent variable lnq does not predict the behavior of acquiring firms' behavior. Although the number of right predictions out of total observation appears impressive, the correct predictions were all non-acquirers.

Several other adjusted q variables were also used as independent variables. The results were about the same. Results of the probit analyses for targets were also not encouraging.
Comparisons with Related Studies

Comparisons with the Results of Chappell and Cheng's Study

The result of the paired comparison t-test, the significantly higher q-values of acquirers compared to those of control firms, indicates high q-value firms engage in mergers more actively than lower q firms. Thus, the behavior of acquirers can be justified as a result of a value maximizing process. This result is consistent with the results of Chappell and Cheng (4), who studied the relationship between the percentage of assets acquired by mergers to the book value of total assets and several financial data including q ratio using Tobit analysis.

Although the results of this study are similar to Chappell and Cheng's, the methodology employed is quite different. Chappell and Cheng estimated Tobit equations for each sample period from 1971 to 1978. The dependent variable used was the percentage of assets acquired by merger to the book value of firm's total asset in the year preceding merger. Leverage, profitability, liquidity, growth, firm size, and q were used as independent variables. Among them, q and profitability were found to be important explanatory variables from Tobit analysis.

The methodology employed in the present study is a case-control methodology in which control firms were matched by size and industry classification. Only q-value is used
in this study, because \( q \) summarizes all investment opportunities of a firm, according to \( q \) theory of investment. A paired comparison t-test was used to see whether there is a significant difference in \( q \)-values between experimental and control firms.

**Comparisons with Hasbrouck's Study**

Concerning the characteristics of target firms, Hasbrouck (13) tried to discern the differences in financial characteristics of targets from non-target firms. Hasbrouck also attempted to determine the causal mechanism of the differences, whether firm-specific or industry-related. Target firms are found to have low \( q \)-ratios and high current financial liquidity. Hasbrouck also found that the events giving rise to the differences in \( q \) are firm-specific, while the events to the liquidity are industry related.

The methodology employed in Hasbrouck's study was a multinomial logit analysis with case-control sample selection methods in which control firms were matched by either size or industry classifications.

Unlike Hasbrouck's results, the observed acquired firms and their controls in this study did not have significantly different \( q \)-values. Although statistically not significant, the control group had a nominally smaller \( q \)-value than that of the acquired group. This result not only is inconsistent with that of Hasbrouck (13) who found that target firms are
generally characterized by low q ratios, but does not support the Hypothesis II proposed, that targets' q-values should be lower than those of control firms.

The differences in results from Hasbrouck could be attributed to several sources, although most methodologies to calculate Tobin's q are very similar. Hasbrouck (13) selected two control groups—one control group was size matched, the other was industry matched. In this study, both size and industry are matched at the same time to select one control group of firms. Since the objective of finding a matched firm is to find a firm which has similar characteristics, it would be better to control for as many confounding variables as possible.

Hasbrouck used SEC reported replacement cost as the estimate of the replacement value for those firms who reported replacement value data. For those firms which did not report replacement value, an estimate was made using the same methodology adopted in this study. The SEC gives considerable leeway to firms' calculation of replacement value; this may cause bias if both SEC reported and estimated values are used in a t-test. The result of this study, which uses the estimate exclusively, is better in that internally consistent data is used.

This study employed a paired comparison t-test, while Hasbrouck used a t-test for the difference between means.
When the assumption of two random independent samples is not satisfied, a paired comparison test for matched samples is recommended (10, 29). Further, the t-test normality assumption was untested in Hasbrouck's study.

The essential difference between Hasbrouck's and this study lies in their approaches to handle size and industry effects. In this study, size and industry effects were removed by selecting control firms matched by both industry groupings and size to see whether there is a significant difference in q-values between target and control firms. In other words, only firm-specific effects of q-values matter in this study.

On the other hand, Hasbrouck tried to discern both firm-specific and industry related effects, by selecting two control sample firms. One is size matched, the other is industry matched. Hasbrouck claimed (13, p. 360) that size matched analysis reflects both firm and industry effects, while industry matched analysis reflects only firm effects. The claim implicitly assumes that there is no size effect involved. Although the size of firms was limited to relatively large firms (one hundred million dollars of market value), it might include residual size effects when the size of control firm was significantly different from that of target in industry matches.
Summary and Discussion

Tobin's \( q \) calculated by the methods described in Chapter III was generally low compared to a hypothetical equilibrium value of one, using either of two different weighting schemes. The values ranged from the mid .70s to the high .90s. The reason average \( q \)-values were consistently lower than one for the whole sample period is unknown. However, this finding seems consistent with the other studies.

Lindenberg and Ross (18) provided the plot of the average economy wide \( q \) of four different sources for the years 1960 through 1977. The three sources other than Lindenberg and Ross's were the Economic Report of the President, Von Furstenberg, and Tobin and Brainard. All four studies show that the economy wide \( q \)-values were around one from 1974 to 1977, though very high \( q \)-values were observed before 1973 in all studies.

The responsiveness of sample and control firms \( q \)'s to the market trend of \( q \) were not markedly different from each other. Several different adjustment regressions produced essentially the same results, insignificant slope coefficients.

A paired comparison t-test provided enough evidence to infer that the average value of log transformed \( q \) values for the acquiring firms was significantly higher than that of
the control group of firms. The variable Inq satisfied the most important assumption of t-test--normality. This indicates that Tobin's q may measure a firm's investment opportunities. This finding is not only consistent with Hypothesis I that the average q of acquiring firm is higher than that of control group, but provides some evidence of an allocationally efficient market of takeovers. This result is also consistent with the results of Chappell and Cheng (4).

Unlike acquiring firms, acquired firms and their controls do not have significantly different q-values. Although not statistically significant, the control group had a nominally smaller q-value than that of the acquired group. This result not only is inconsistent with that of Hasbrouck (13), who found that target firms are generally characterized by low q ratios, but does not support the Hypothesis II.

Merger officially requires consent of both an acquirer and a target firm. However, acquirers usually initiate the merger talks. Thus, a target firm's decision to merge with an acquirer, especially after the acquirer initiated long talks, persuasion and sometimes threats to make a public tender offer, could be against the target's will. Therefore, there seems a need to distinguish between two types of target firms, willing to merge or forced to merge.
because the theory of investment assumes free will to invest. The fact that two thirds of tender offers are followed by formal mergers (9, p. 352) provides evidence of the existence of unfriendly mergers. Sample firms in this study may include both types of targets.

The rejection of Hypothesis II may result from the failure to distinguish between these two types of targets. In this regard, higher q values for target than that of control, though statistically insignificant, could be explained by the rational investment behavior of acquiring firms. The higher q a target has, the better a merger partner it would be.

Although variable lnq was found to have statistically different means between acquirer and control, lnq alone was not enough to be used for prediction purposes. Thus, Hayashi's claim (14, p. 218) that all the investment opportunities of a firm are summarized by q was not empirically supported in this study.
CHAPTER BIBLIOGRAPHY


22. Miles, J. A. and J. D. Rosenfeld, "The Effects of Voluntary Spin-Off Announcements on Shareholder


34. Stevens, D. L., "Financial Characteristics of Merged Firms: a Multi-Variate Analysis," *Journal of*
Financial and Quantitative Analysis, 8 (March, 1973), 149-158.

CHAPTER V

SUMMARY

This chapter provides a brief summary and conclusion of the study. In addition, a few suggestions for future research on the relations between Tobin's q and takeovers are made.

Summary

The primary purpose of the study was to investigate whether takeover markets are allocationally efficient using Tobin's q as the variable which summarizes the investment opportunities of firms. Another purpose was to determine whether Tobin's q could be used to improve predictions of merger events.

Chapter II presented the review of literature on takeovers and theory of investments. Many aspects of takeovers were discussed at length. The development of investment theory was summarized to present the connection between neoclassical theory of investment with adjustment cost and Tobin's q theory of investment. It has been known that Neoclassical theory of investment with adjustment cost is equivalent to Tobin's q theory of investment (2). Since
Neoclassical theory of investment seeks an investment rule which maximizes the present value of an firm. Tobin's q also summarizes information on the investment rule to maximize firm value.

Thus, high q firms should invest to increase the value of firms, in an allocationally efficient market. On the other hand, low q firms should disinvest voluntarily. Takeovers, an external investment, are selected as a form of investment to check whether firms behave according to the q theory of investment. Two research hypotheses were formulated.

1) Acquiring firms' q should be significantly higher than that of control firms, on average.

2) Target firms' q should be significantly lower than that of control firms, on average.

Chapter III presented the research design adopted to test the above hypotheses. The methodology to calculate q values and methods to reduce the bias which may result from choice-based sampling were also made. Since two independent random samples cannot be selected in this study, control sample firms were selected by matching to ensure that matched pairs had similar characteristics. Industry classification and size were used as two confounding
variables. The justification of using matching and adjustments to different responsiveness to the trend of market was also described. Target firms were selected from the COMPUSTAT RESEARCH tape. Acquiring firms were found in the Wall Street Journal Index. Control firms were chosen from the COMPUSTAT INDUSTRIAL tape.

Although marginal $q$ is the appropriate concept for a theoretical optimum investment rule, average $q$ was used as a proxy. Lindenberg and Ross's methodology (with slight modifications) was employed to get $q$ values. The calculated $q$ values were planned to be adjusted according to the responsiveness to market trend. However, the regression coefficient (slope) was not significantly different from zero. The justification for using Probit analysis to check predictive ability of $q$ for takeover events was also presented. The problems related to the choice based sampling and its corrective measure were discussed.

Chapter IV presented the results of the study. To calculate market value of bonds, bond ratings were predicted for those whose ratings were not available. Moody's Bond Records were used to collect the bond ratings of sample firms. SAS STEPDISC procedure was used to select a small number of discriminating variables. Using the selected variables by SAS STEPDISC procedure, discriminant analysis was used to predict bond ratings of firms. Ex-post internal
classification rates were calculated to compare the predictive ability of discriminant models.

To calculate average value of q, both equal- and market-value weights were used. Shapiro-Wilk's statistic was used to test normality of q. After the values of q were tested for normality, paired comparison t-tests were performed for two pairs. One pair was target firms and their control firms; the other was acquirers and controls. It was found that the average of log-transformed q value for the acquirers was significantly higher than that of the control group, while targets and control did not have significantly different q values.

The results of probit analysis showed that q alone could not predict the acquirers of takeover events. However, q-value was found to be an important explanatory variable around the merger announcement period.

Conclusion
The significantly higher value of lnq for the acquirers than that of its control suggests that the behavior of acquirers is consistent with the implication of allocationally efficient takeover markets. On the other hand, target firms' behavior is not consistent with the Hypothesis II proposed. The predictive ability of q on the occurrence of takeovers was very small.
The rejection of Hypothesis II, targets' q-values should be significantly lower than those of control firms in an allocationally efficient market, might not be in conflict with the implication of allocational efficiency concepts. This rejection could result from the failure to identify target's motive to merger—voluntary or not.

Suggestions for Future Research

Based on the findings of the study, several suggestions are made. First, q theory of investment could be applied to voluntary spin-offs and sell-offs studies (3, 5, 6), whether their q values are, on average, smaller than those of other companies. Spin-offs or sell-offs are usually not forced by others, unlike mergers or tender offers. Even when a firm is forced to do so by the courts, a motive is easy to identify. Thus, the disinvestment behavior of firms may be studied more accurately. Tobin's q might be helpful to study other corporate events such as corporate failures.

Second, the development of a proxy which is theoretically closer, and is empirically tractable, to the concept of marginal Tobin's q is needed. As warned by Hayashi (2), the use of average q rather than marginal q may give biased results in investment related studies.

Third, since this study used only one explanatory variable, that is, q, it is possible that other measures based on financial statements may aid prediction of takeover events.
CHAPTER BIBLIOGRAPHY


Appendices
# Appendix A

## List of Experimental Firms

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## Appendix B

### LIST OF CONTROL FIRMS

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* represents firms deleted from final sample
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## Appendix C

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<td>Long-term Debt</td>
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<td>Preferred Stock at Liquidating Value</td>
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<td>x12</td>
<td>Net Sales</td>
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<td>x13</td>
<td>Operating Income Before Depreciation</td>
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<td>x14</td>
<td>Depreciation and Amortization</td>
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<td>x15</td>
<td>Interest Expense</td>
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<tr>
<td>x18</td>
<td>Net Income</td>
</tr>
<tr>
<td>x24</td>
<td>Market Price of Common-Close</td>
</tr>
<tr>
<td>x26</td>
<td>Dividends per Share</td>
</tr>
<tr>
<td>x58</td>
<td>Earnings per Share (Primary)</td>
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* i in variable name xi denotes COMPUSTAT item number
Appendix D

THE RESULTS OF HOMOGENEITY TEST

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<tr>
<th>Year</th>
<th>Four class Chi-square</th>
<th>Six class Chi-square</th>
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<tr>
<td>1968</td>
<td>-6.67</td>
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<td>82.35 *</td>
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<td>1971</td>
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<td>17.75</td>
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<td>1973</td>
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<td>1974</td>
<td>114.22 *</td>
<td>443.27 *</td>
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<td>1975</td>
<td>149.85 *</td>
<td>562.97 *</td>
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<td>1977</td>
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<td>1978</td>
<td>82.14 *</td>
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<td>1979</td>
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<tr>
<td>1981</td>
<td>78.11 **</td>
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<td>1982</td>
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<td>365.60 *</td>
</tr>
</tbody>
</table>

*-significant at 0.05 level
**-significant at 0.01 level
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Shapiro, S. S. and M. B. Wilk, "An Analysis of Variance Test for Normality (Complete Samples)," Biometrika, 52 (December, 1965), 591-611.


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