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THE INFORMATION CONTENT OF DIVIDENDS: AN EMPIRICAL ANALYSIS OF WARRANTS CONDUCTED BY EXAMINATION OF THE IMPLIED VARIABILITY OF STOCK PRICES

University of Illinois at Urbana-Champaign PH.D. 1983

THE INFORMATION CONTENT OF DIVIDENDS: AN EMPIRICAL ANALYSIS OF WARRANTS CONDUCTED BY EXAMINATION OF THE IMPLIED VARIABILITY OF STOCK PRICES

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THESIS

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Accountancy
in the Graduate College of the
University of Illinois at Urbana-Champaign, May, 1983

Urbana, Illinois

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

THE GRADUATE COLLEGE

MAY, 1983

WE HEREBY RECOMMEND THAT THE THESIS BY

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ENTITLED THE INFORMATION CONTENT OF DIVIDENDS: AN EMPIRICAL ANALYSIS OF WARRANTS CONDUCTED BY EXAMINATION OF THE IMPLIED VARIABILITY OF STOCK PRICES

BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

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DEDICATION

I would like to dedicate this project to my mother and father to thank them for their inspirational support throughout my education. Their dedication and commitment to a job well done set an example for me that has been a motivating force all my life. It is from them I have acquired my work ethic.

My father's quartermaster skills (for organization) and his bookkeeping talents (meticulous attention to detail) undoubtedly structured my learning. He, himself, was an accountant who taught me, by example, independence and personal ethics. It is also from him that I learned to give one hundred percent, irrespective of the cost. Although he supported and witnessed the insemination of this degree, I am deeply sorry he could not be here for its conclusion.

It is my mother who provided the incentive to see this project through to its end. It was she who, on the first day of school, dragged me to kindergarden screaming in protest. She spent countless hours helping me write and rewrite painful themes, essays, and book reports. She picked me up at the principal's office when I got in trouble and drove me home when I got hurt. She was literally on call throughout my education. From her I got self-discipline, integrity, tenacity (guts), and absolute dedication to a task until its completion. She never quits or gives up. Were it not for her steadfast enthusiasm, unselfish encouragement, tireless help and support, and patient understanding, I would not have finished this project. This degree is at least part hers.

ACKNOWLEDGEMENTS

I would like to thank my committee members for their valuable comments, support, and assistance: Professor Thomas J. Frecka (Chairman), Professor James C. McKeown (Director of Research), Professor Peter A Silhan, Professor John E. Gilster, Jr., and Professor Cheng-few Lee. I am indebted to them for their patience and commitment. Remaining errors are, of course, the responsibility of the author.

I would like to thank my colleagues from the University of Illinois for their advice, friendship, and tolerance: Randy Beatty, Vic Bernard, Vic Defeo, and Steve Kaplan. Because this debt was incurred as a fellow-student, it can never be repaid.

I would also like to thank the participants in workshops at the University of British Columbia, University of Michigan, University of Oregon, and University of Rochester. Comments and suggestions from Eduardo Schwartz and Clifford Smith were especially useful. A special thanks is due Rex Thompson who suffered through numerous versions of this manuscript and provided invaluable technical assistance on the research design.

I would also like to thank my support people: Barbara Strouts for typing, Nancy Thompson for word processing, and Don Hofmann for computer programming.

Finally, I would like to formally thank my friends for their moral support throughout this degree: T.J. Jacob (Jake), Charles E. Wilson (CEW), and the entire Scottswood and Embassy crews.

Last (but not least), I would like to thank Julie A. Lockhart (Jewels). She, alone, had to put up with me on a daily basis throughout this ordeal. Without her cheerful and smiling face, profound optimism, undauntable patience, and revitalizing support, this thesis would never have been finished.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 The Role of Information

One function of "financial" accounting is to provide information in the form of public disclosures that help facilitate the decision-making process of market participants (i.e., external users). In a general sense, the role of these informative disclosures is to alter beliefs. Beaver [1976; pp. 67-68] has noted that information cannot, in and of itself, suggest which (set of) action(s) is best because it lacks one important quality: it does not contain a preference ordering across consequences. While it may alter beliefs about the likelihood of certain outcomes conditional on various actions, it provides no basis for selecting among feasible alternatives. In other words, the informative disclosure merely provides a (set of) signal(s) to which (aggregate) market reaction is the response. Notice that information can no longer be characterized simply as the reduction of uncertainty; that definition was predicated on the implicit assumption that to be useful, information had to be non-ambiguous.

Traditionally, the role of accounting disclosures has been investigated in information content studies. In a comment by Beaver [1981] about the contemporaneous relationship between security prices and accounting earnings, a definition of "information content" is provided:

> ..., if earnings alter investors' beliefs about the attributes that cause securities to be of value, a statistical dependency between earnings and security prices can arise. Security price research refers to this statistical dependency as information content. (p. 117)

The concept of statistical dependency in that definition applies with equal force to any accounting announcement.

Accounting: A Measurement and Communication Process

Accounting is often characterized by two processes: measurement and communication. These interrelated functions involve two basic steps: first, information is produced; second, it is disseminated.

Gonedes, Dopuch, and Penman [1976] suggest that this broader characterization of the accountant's disclosure function requires analysis of two fundamental issues:

(1) The extent to which the type of information (i.e., signal) to be disclosed conveys information pertinent to valuing firms; and

(2) The extent to which the particular disclosure contributes to the optimal allocation of resources.

This first consideration is labeled the "information content" issue. The firm is viewed as a "monopolist" in the market for information about itself. Through certain accounting disclosures, management can signal changes in its expectations about future prospects of the firm or, at least, signal confirmation of prior assessments by the market.

The second consideration is labeled the "resource allocation" issue. A comparison of existing institutional arrangements (i.e., market failure vis-à-vis mandated disclosure rules) is made. Characterization of information as a "public good" necessitates that an appropriate system of property rights be established to deal with the informational externalities (i.e., assymetries) and exclusion (i.e., free-rider), moral hazard, and adverse selection problems. This cost-benefit orientation, in turn, leads to a discussion of the mechanism through which resource allocation should be affected by information production and dissemination. Although the second consideration is drastically important to the discipline of accounting, it is considered beyond the scope of this research.

Discretionary Signalling

This study addresses the first issue. If information is defined operationally as a change in expectations about the outcome of an event that is sufficiently large so as to induce a change in the decision-makers' behavior (See Beaver [1968; pp. 68-69]), then an accounting disclosure can possess informational value only if it leads to an altering of the optimal holding of that firm's stock. As such, accounting information constitutes a proper subset of information in general.

It is useful to dichotomize this subset into two broad categories:

(1) Formal accounting documents, such as financial statements, audit reports, or registered filings.

(2) Informal accounting documents, such as quarterly dividend announcements, news media releases, or forecasts.

The second category of disclosures seems particularly interesting. Unlike the first in which management is constrained by rigid format or reporting requirements to summarize its historical results, it permits management to overtly signal its expectations about the firm's prospects. Aharony and Swary [1980], Gonedes [1978], Ross [1977], and others have pointed out that management would probably be reluctant to use this discretionary, informal signaling falsely, because when the underlying results are revealed, the usefulness of these signals (for future signaling) would be dramatically reduced. In this study it is assumed that corporate signaling entails management behaving as if it were providing observables to the market from which agents can presumably make inferences about unobservables. This stimulus-response perspective is exploited in the current study.

In the free market setting a firm has available to it a large number of ways it can issue signals to outsiders. Some of these means are relatively costly (see Bhattacharya [1980] for a distinction between dissipitative and non-dissipitative signals). Some of these signals are routinely redundant.

A large body of empirical research documents that stock prices react to announcements of unexpected dividends.[1] However, the results of testing for a stock price reaction to the dividend announcement, itself, and not an unexpected or a sufficiently large change in that announcement, have been less conclusive.

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[1] See Kalay [1982], Fama, Fisher, Jensen, and Roll [1969], Pettit [1972], Laub [1976], Charest [1978], Aharony and Swary [1980].

The purpose of this study is to examine one particular type of management signal implicit in the dividend announcement. A methodology derived from an equilibrium option-pricing model is employed.

1.2 Variable of Interest: Dividend Announcements

The Irrelevance Proposition

One of the most important signals any individual market participant can receive is the announcement of cash dividends. In that dividends constitute actual monetary return to investors for their investment decision, this firm-specific accounting signal seems to be a particularly interesting candidate for analysis. On the other hand, it is also interesting because it appears on the surface to be diametrically at odds with the famous "irrelevance proposition." That proposition, formulated by Miller and Modigliani [1961], established that in perfect capital markets and for a given investment policy, the market value of the firm is independent of its dividend decision. Confusion about the implications of this proposition arises, however, because of a sufficiently well-documented empirical regularity evidencing a stock price reaction to the dividend announcement. The most frequently cited explanation of this empirical phenomenon is labeled "The information content of dividends hypothesis". This proposition specifies that dividends convey information about the future cash flows of the firm, over and above that which is already known to the market from other sources (Kalay [1982]). Miller and Modigliani [1961] emphasize this distinction, noting:

> ... (I)n the real world a change in the dividend rate is often followed by a change in the market price (sometimes spectacularly so). Such a phenomenon would not be incompatible with irrelevance to the extent that it was merely a reflection of what might be called the 'information content' of dividends ... (p. 430)

Based on the separation principle (i.e., the separability of the investment and financing decisions), Miller and Modigliani demonstrate that, for a given firm's investment strategy, the dividend payout policy it chooses to follow will affect neither its share price nor the (total) return to its shareholders. The value of a firm, therefore, is determined solely by the "earning power" of its existing assets and its investment policy, and <u>not</u> by how these results are "packaged" for distribution (p. 414).

<u>The Information-Content Hypothesis</u>

This information-content-of-dividends hypothesis has been evolving for over twenty-five years. Lintner [1956] was one of the first to suggest that current dividends depend on not only current (and past) earnings, but also <u>(expected) future earnings</u>. Subsequently, a dispute over the dependence of a firm's market value on the (capitalization) rate at which dividends are paid out of earnings (i.e., the dividend payout rate) developed (Watts [1973; p. 191]). Again, it was Modigliani and Miller [1958] who provided the seminal analysis on share valuation.

Gordon [1962, 1963] however, repeatedly argued that a firm's dividend policy could affect its share price. The essence of his argument was that risk-averse investors are likely to perceive current dividends as less risky than future, uncertain ones (this has come to be known as the classic "bird in the hand ..." argument). Consequently, he surmised a corporate decision to reduce current, in favor of increased future, dividends will reduce current market (share) price, even when the funds are invested to yield ($\geq$) the firm's cost of capital.

Higgins [1972] has extended Miller and Modigliani's arbitrage proof of the irrelevance of dividends to the case of increasing uncertainty over time. In both the no-growth firm and the growth firm (general) cases, Higgins demonstrated that, under the assumed market conditions, "home-made dividends" in the form of periodic shareholder liquidations are a perfect substitute for corporate distributions, even when risk varies with the futurity of returns (p. 1761). These proofs by Higgins demonstrate that share prices are independent of dividend policy even when the current dividends are perceived to be less risky than future ones. However, to say that share prices (i.e., market value) are independent of dividend policy does not invalidate the information-content-of-dividends hypothesis. On the contrary, it clarifies the role of dividends as a discretionary signal.

The purpose of the foregoing analysis is to carefully delineate between two independent roles (or theories) of dividends. Even though a firm's dividend policy has no effect on its share price or market returns, it can still serve an alternative purpose: it may constitute a signaling device that management can use to convey information to the public. This characterization suggests dividends are a <u>lead</u> not a lag variable providing management with a recurring format to signal its expectations.

Assuming that management possesses "inside" information about the firm's future prospects, it can use these cash dividend announcements to signal changes in its expectations. Miller and Modigliani [1961] claim:

> ... (I)nvestors are likely to (and have good reason to) interpret a change in the dividend rate as a change in management's views of future profit prospects for the firm. The dividend change, in other words, provides the occasion for the price change though not its cause, the price still being solely a reflection of future earnings and growth opportunities. (p. 430)

Interpreting dividend changes as potential signals stems from early work by Lintner [1956] and Brittain [1966], among others, on dividend decisions. In their work, managements are presumed to behave as if they select (enact) dividend changes according to a target payout ratio and their expectations about future values of income numbers. Gonedes [1978] observes these expectations may be conditional on information not yet available to "outsiders." He comments:

> ... (I)f investors behave as if income numbers are effective signals vis-à-vis unobservable attributes of firms' decisions, they may behave as if dividend changes reflect information beyond that currently available to outsiders. (p. 27)

In addition, he observes that the implications of accounting numbers may vary across time as well as across firms; they may also vary as a function of the characteristics of other contemporaneously available signals in the market (p. 30). These observations are of particular concern in this study with explicit attention given towards controlling for their effects.

Aharony and Swary [1980] observe, since dividend decisions are made almost solely at management's discretion:

> (A)nnouncements of dividend changes should provide less ambiguous information signals than earnings numbers. (p. 1)

Furthermore:

> ... (G)iven the discreet nature of dividend adjustments, signals transmitted by these changes may even provide information beyond that conveyed by the corresponding earnings numbers. (p. 1)

The market's anticipation of the (information content of the) dividend announcement, as reflected in stock price changes leading up to and immediately following their release, would be evidence that investors' beliefs were being altered. This observed revision of stock variability implied by stock and warrant prices associated with the dividend signal reflects the flow of information to the market and is taken as an indication that the disclosure is useful (cf., Ball and Brown [1968]).

Review of Previous Information-Content-of-Dividends Studies

While there has been extensive empirical research addressing the information content of dividends issue, the existing evidence is inconclusive. Classically, prior studies have involved a testing methodology structured around some form(s) of a dividend expectations model(s) and residual analysis. In addition, they have focussed exclusively on the behavior of realized stock prices around the dividend announcement, limiting their sample of firms to those reporting a significantly large increase or decrease in the dividend payout.

Fama, Fisher, Jensen, and Roll [1969] observed that past stock splits have often been associated with substantial dividend increases. They concluded that when there is detectable reaction surrounding a stock split, it is only the market's reaction to the dividend implications of the split, and not the split, per se. That is, the split causes price adjustments only to the extent that it is associated with changes in the anticipated level of future dividends.

Watts [1973] and Gonedes [1978], on the other hand, suggest that dividend announcements are redundant. They infer that dividends contain no information beyond that which is already available in contemporaneous income signals. Watts [1973], using annual earnings and dividend per share data, regressed future annual earnings on current and past earnings and dividends. In his time-series tests he found the relationship between current dividends and future earnings was positive, but not very strong (in his words, "trivial" [p. 211]). He had originally hypothesized that dividends conveyed information beyond that conveyed by earnings numbers. Information (i.e., the unexpected change in dividends) was defined as the difference between current dividends and expected dividends, conditioned on current earnings. He regressed changes in future earnings on unexpected dividend changes, and the signs of those changes. In both cases, he found the relationship to be very weak (p. 193). Gonedes [1978], also using annual data, reached similar conclusions with respect to annual dividends (as well as the extraordinary-item signal).

Using quarterly data, Pettit [1972, 1976] and Laub [1976] found that market participants do use information implicit in dividend announcements. Pettit [1976] attributed differences between his finding and the Watts [1973] findings to differences in their classification schemes. Pettit claimed he was able to generate consistent results by restructuring the methodology (p. 98). Watts [1976b] later claimed that Pettit's dividend and earnings variables were misspecified (pp. 104-106).

Laub [1976], also using quarterly data, concluded that there did seem to be information in the dividend announcement (p. 80). He posited three plausible models of the dividend-earnings relationship and concluded that even after consideration of the improvement in forecasting ability obtained by going from an annual to a quarterly earnings forecasting model, there still seems to be incremental informational value in the dividend announcement.

Charest [1978] suggested that trading strategies based upon the announcement of large dividend changes may lead to abnormal returns.[2] However, he warned that it is difficult to isolate dividend effects from other (closely synchronized) effects (p. 298).

Aharony and Swary [1980] employed a methodology that included only quarterly dividend and earnings announcements made public on different dates within a given quarter. They distinguished between earnings announcements that precede or follow from those that accompany (i.e., interact with) dividend announcements. They found that these independent dividend announcements have the same effect as that

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2 Note: Charest ignores the differential tax structure affecting ordinary (dividend) income vis-à-vis capital gains.

of their total sample of announcements. Their results indicate that earnings announcements alone cannot explain the observed behavior of stock prices around dividend announcements. They concluded that market reaction to the dividend announcements seemed to support the hypothesis that changes in quarterly cash dividends provide useful information (p. 11).

The Wealth Transfer Hypothesis

Galai and Masulis [1976], Jensen and Meckling [1976], Smith and Warner [1976], and Kalay [1982] among others have suggested a competing hypothesis that explains why the announcement of unexpectedly large (small) dividends drives an increase (decrease) in stock price. Kalay [1982] claims that unexpected dividend changes would redistribute wealth from bondholders to stockholders if they are financed by the issuance of new debt (of the same or higher senority than existing debt) or by reducing investment outlays (p.3). Like the information-content-of-dividends hypothesis, this "pure-wealth-redistribution hypothesis" is consistent with the irrelevance proposition that dividend announcements have no effect on the market value of the firm. In fact, the information content and wealth transfer hypotheses are not necessarily mutually exclusive (Kalay [1982, p.3]). However, like most prior tests of the information-content hypothesis, tests of the wealth-redistribution hypothesis are also ex-post in nature. This study employs an ex-ante methodology that focuses on the aggregate market's response in anticipation of the announcement. The power of most previous empirical tests of this phenomenon was predicated on a significantly large change in dividend behavior. The methodology employed here is not so restrictive.

1.3 Selection of Equilibrium Relationship

Information Content Methodologies

Portfolio theory is constructed on the premise that there is a tradeoff between risk and return (see Fama [1976; Chapter 7]). A change in a firm's risk, as evidenced by an increase in the variability of its stock price, would be an indication that the market was reacting to or anticipating the disclosure of new information, and would also imply a rebalancing of that stock's position in investors' portfolios. In this study it is hypothesized (cf., Patell and Wolfson [1979a, 1981]) that examination of the time series behavior of warrant prices attendent to a disclosure event can reveal increases in security price variability, even though the signal may have no observable effect on mean stock prices. This increased variability is taken to be an indication of the information content of the particular announcement.

Traditionally, "information content" studies have been based on a methodology derived from the capital asset pricing model (CAPM), (e.g., Ball and Brown [1968], Fama, Fisher, Jensen, and Roll [1969], Joy, Litzenberger and McEnally [1977], etc.), where some unexpected or abnormal residual (the API or CAR metric generated via some return expectations model(s)) is correlated with the sign and/or magnitude of the forecast error (generated via some earnings expectations model(s)). Patell and Wolfson [1979] categorize these studies as "ex post" analyses[3] because they observe what a large sample of security prices actually did on the date (or immediately thereafter) of an accounting disclosure. To the extent that the CAPM, itself, is constrained by theoretical shortcomings,[4] the conclusions of prior empirical studies are not altogether unexpected. As Ross [1978] has pointed out: (paraphrased)

> Testing the CAPM or any other theory, for that matter, cannot be done in isolation; there must be a viable alternative to the theory under discussion (p. 894). ... (T)he attractiveness of the CAPM is due to its potential testability. It is a paradigm, precisely because it is cast in terms of variables which are, at least in principle and with the usual exception of the ex ante--ex post distinction, empirically observable and statistically testable. Its positive orientation and apparently simple intuition have made it the central equilibrium model of financial economics, and it is definitely not, as some have suggested, merely a particular example of parameterization of a rather simple general equilibrium model. On the other hand, it is also not, as some enthusiasts believe, the only or merely the 'best' possible model. (p. 885)

Ross [1978] proposes an alternative equilibrium model, the arbitrage pricing theory of capital assets (APT)[5] which might also be considered for empirical testing. Ross' arbitrage argument, however,

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3 The concepts of "ex post" and "ex ante" analyses as used here by Patell and Wolfson are not to be confused with their more traditional usage. See for example, Mayers and Rice [1979], Roll [1978], or Fama [1976].

4 Roll, [1977], Ball [1978], and Ross [1978] have discussed both the theoretical limitations as well as empirical implementation problems at length.

5 See Ross [1978; p. 893] for model specification.

follows very closely to the riskless hedging arguments employed by Black and Scholes [1973] and Cox and Ross [1976] in deriving their option pricing relations. Although Ross' model has numerous desireable attributes, it does not allow (mechanically) for the underlying stock's variability to be implied. This particular feature is unique to the option pricing formula. This study incorporates an algorithm which exploits that capability.

The option pricing model specifies an equilibrium pricing relation that contains both a "primitive" and "derived" asset. Patell and Wolfson [1979] have noted:

> Call options provide a particularly appropriate instrument for this type (information content) of research because of the relationship between their value as a contingent claim and investor beliefs about the future stochastic behavior of the underlying stock price over the remaining life of the option contract. (p. 118)

Analysis of the interrelationship of these two assets, in equilibrium, provides new information on the distributional properties (specifically, the second moment) of the security price formation process.

A methodology extracted from an equilibrium pricing model for call options is used. Various adjustments are made to the model to accomodate warrants.[6]

Ex-Ante Methodology

Traditionally, residual analysis techniques (based on the CAPM) presume that no (ex post) change in mean stock price indicates no

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6 See Chapter 2 for a differentiation of features.

information content in the accounting disclosure. This interpretation may be fallacious. It is conceivable that the market has priced the security "correctly" and that the information released merely confirms these expectations. It is suggested here (cf., Patell and Wolfson [1979; p. 118]) that examination of the time-series behavior of warrant prices (leading up to and passing through the disclosure event) can reveal increases in security price variability, even though the signal may have no observable effect on mean stock price. If market participants expect the date of (and/or surrounding) an information release to be a period in which stock price variability is temporarily "above average", this methodology could indicate whether or not the participants perceive disequilibria. This increased variability reflects a temporary lack of consensus among the capital market agents as to the meaning (i.e., content) of the about-to-be-released disclosure.

Ohlson's [1979] analysis of "disclosure environments" indicates that the variability of stock price (and return) should be relatively large at the time information is disclosed. "Put simply", he explains, "the disclosure of information precipitates the need for a revaluation of the asset" (p. 227). Although actual signal realization may drive a shift in the firm's mean stock price, it is anticipation of that signal that drives an increase in its <u>variance</u>.

The relationship between a contingent claim and its underlying asset is important for another reason. Whereas the valuation of a firm's common stock is based directly upon its expected dividend stream[7] and its (relative) risk to the investors, the valuation of a firm's options (or warrants) is <u>indirectly derived</u> in relation to the value of the underlying common stock involved. To the extent that there is "risk" associated with the option itself, as well as the underlying asset, it could be argued that options are more "sensitive" (volatile) than ordinary securities (e.g., common stock, preferred stock, bonds, etc.) and correspondingly a better barometer of information content.

Although researchers have investigated the so-called information content of various accounting-related signals, the evidence has, to a large extent, been inconclusive. Perhaps it is because, as Ball [1978], Brown, Kleidom, and March [1982], Reinganum [1981], and others suggest, the pricing relation, itself, has been misspecified (intertemporally or with respect to missing variables), incorrect expectations models have been utilized, or beta is unstationary.

An alternative approach adopted here makes use of an option-pricing methodology which is derived from a different equilibrium relationship. By using current stock price and the related warrant price, stock variability can be implied. Reaction to a forthcoming disclosure (the dividend announcement) might be detected by employing this relationship to capture this ex-ante, anticipation effect.

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7 Miller and Modigliani [1961] have demonstrated that, under the assumptions of (a) perfect capital markets, (b) rational investor behavior, and (c) perfect certainty (i.e., determinism), the (1) discounted cash flow (DCF), (2) the current earnings and future investment opportunities, (3) the stream of earnings, and (4) the stream of dividend approaches will all generate an identical valuation for a firm's outstanding common shares.

Size Anomaly

A concomitant issue is also be addressed in this study. There exists a growing body of empirical documentation providing evidence of a "size anomaly". The issue raised here is not whether the market, characterized as some aggregate structure which serves to clear financial transactions between economic agents, impounds some subset of available information in an unbiased and instantaneous manner (i.e., is efficient or not). Rather, the concurrent issue examined in this study is whether or not firm size is systematically related to the level or degree of market efficiency. Presumably the information search and processing costs would be higher for the relatively smaller firms. This study investigates whether firm size has a differential impact on the ex-ante anticipation of a dividend announcement.

Summary

Firms routinely issue certain accounting signals. These signals are categorized as "accounting" signals because they represent the culmination of the accounting measurement and communication process. They may be used to signal confirmation of historical results as well as expectations regarding future operations. The signal itself allows differential information as well as diverse beliefs to be aggregated into a single summary assessment. This assessment, when issued, becomes an observable to market agents, from which they can draw inferences about unobservables to make investment decisions. Thus the signal can be viewed as a stimulus to which market reaction is the response.

This study focusses on one type of signal and one aspect of that response. It examines the implied variability of stock prices on days leading up to and passing through the dividend announcement calculated from a sample of firms with actively traded warrants. By employing a methodology devised by Patell and Wolfson [1979], the ex-ante market effect of this accounting disclosure can be scrutinized allowing inferences about investors' (and classes of investors') anticipations to be made. This is a study of the information content of dividends; <u>not</u> a study of the realized price reactions to the announcement of a dividend change.

The remainder of this study is organized as follows: Chapter 2 develops two versions of the option pricing model from which the variable of interest, the implied standard deviation of common stock return, is generated. Chapter 3 explicates the methodological procedures that are employed to facilitate tests of the information-content-of-dividends hypothesis. Hypotheses are formulated and the empirical results of those tests are presented in Chapter 4. Chapter 5 presents a summary and conclusions of the study and delineates some limitations and extensions.

CHAPTER 2

MODEL DEVELOPMENT

The purpose of this chapter is to develop two versions of option pricing models that will provide the basis for empirical tests concerning dividend announcements. The chapter is organized as follows: section one provides a perspective on the role of contingent claims markets in the economy and explains how such markets can contribute to increased market efficiency. Section two highlights the nature and characteristics of the specific type of contingent claim used in this study - the common stock warrant. A simple, deterministic model is also presented to illustrate how changes in key variables, particularly dividends, impact on warrant prices. Finally, in section three, modern option pricing theory is reviewed. Both continuous and discrete versions of the option pricing model are presented. Dividend and captial structure adjustments are made to these models to allow for tests based on warrants.

2.1 The Role of Options in an Efficient Market

On the surface, it might appear that an options market serves a very superficial or socially unproductive purpose; namely, to provide some legalized form of gambling (i.e., the put and/or call provide a contractual means to bet on the stock market). This, however, is a myopic view of its function.

In his review of the efficient capital markets literature, Fama [1970] stated: (paraphrased)

> (T)he primary role of the capital market is to provide the mechanism which facilitates the allocation of ownership of the economy's capital stock (i.e., resources). The ideal market is one in which prices provide accurate signals for resource allocation: that is, a market in which firms can make production-investment decisions, and investors can choose among the securities that represent ownership of firms' activities under the assumption that security prices at any time 'fully reflect' all available information (however defined). (p. 383)

On the other hand, the primary role of the options market is to provide a mechanism, manifested via private (inter-personal) contracts, which facilitates portfolio diversification by providing a "hedge" on the underlying contingent asset. These contracts simply give the holder the right to buy (call) or sell (put) the common stock of a firm at some specified price.

Ross [1976] has demonstrated that, in the absence of complete markets,[8] the possibility of writing option contracts opens up new "spanning opportunities" and would improve capital market efficiency. Ross cites Arrow's [1971] seminal introduction of the state-space approach to uncertainty in economics as the first formal recognition that an inadequate number of markets in contingent claims would be a source of inefficiency. He points out:

> In the state-space approach the random events that might occur are subsets of elementary points or 'states' in a (probability) space, and the possibility of inefficiency arises whenever the feasible set of pure contingent claims, claims to wealth if a single state occurs and nothing otherwise, fails to span all the state space. (p. 75)

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[8] Complete markets as used here merely implies <u>no</u> state-space exists for which some state-contingent claim is unavailable.

Furthermore, Ross points out that if the number of states (greatly) exceeds the number of marketed capital assets, the competitive equilibrium could be significantly inefficient (p. 76). However, even though there are only a finite number of these marketable assets (i.e., stocks, bonds, equipment, commodities, etc.) which Ross defines as "primitives," there is a virtual infinity of options (or "derivative" assets) that the primitives may generate. It is this possibility of writing option contracts (or a combination of contracts) that is the source of these new spanning opportunities. Essentially this spanning opportunity provides a mechanism whereby the stock risk and the option-writing risk can partly off-set each other to produce a combined investment (i.e., hedged portfolio) which is generally lower in risk than the stock alone.

It would be justification enough for a secondary market that options can be used in conjunction with each other and with other types of securities to produce an almost limitless variety of risk and return combinations, but in addition, as Ross points out:

> ...(I)t is (generally) less costly to market a derived asset generated by a primitive than to issue a new primitive, and there is at least some reason to believe that options will be created until the gains (in an opportunity cost sense) are outweighed by the set-up costs. (p. 76)

Consequently, what was needed was a valuation relationship which spans both markets. This mathematical relationship between the option value and its associated stock value was established by the arbitrage principle that in market equilibrium there are no riskless profits to be made with a zero net investment (Schwartz [1977; p. 80]). This zero net investment portfolio is obtained by taking long and short positions in the stock, the option, and the riskless asset. In efficient financial markets, the (expected) return on such a position would be the risk-free rate. It is from this model for the relative valuation of financial claims that the applications used herein have evolved.

In a market setting, price should impound information about each firm, relative to other firms. If the market is efficient, an equilibrium should obtain where prices "fully reflect all publicly available information." Presumably, information released by or about the firm precipitates the need for revaluation of its securities (Ohlson [1979]). Stock prices, then, should reflect the flow of information to the market. In an analogous fashion, if only indirectly, warrant prices should also reflect that flow through their dependent relationship upon the underlying stock. It is precisely that process which is characterized by the equilibrium option pricing model.

2.2 Differentiation Between an Option and a Warrant

Patell and Wolfson [1979] devised a methodology designed to test for changes in the implied variability of common stock prices. In order to implement that type of methodology some version of the equilibrium option pricing model (OPM) must be adopted. The OPM can be used to characterize the relationship between some "derivative" asset and a "primitive" asset. This derivative asset is referred to as a "contingent claim" (Brennan [1979]) because its payoff depends upon an underlying asset whose value is exogenously determined. This pricing relationship is versatile enough to accomodate many types of derivative assets. In fact, the OPM has been used to theoretically price a wide variety of contingent claims including both European and American puts and calls, the capital structure (i.e., the debt and equity) of a firm, bond covenants, convertible bonds, rights, underwriting contracts, collateralized loans, leases, pensions, insurance and commodity contracts, and warrants.[9] This study examines the time-series behavior of a particular type of contingent claim - actively traded common stock warrants.

Despite the fact that most of the analytical work which preceded formulation of the OPM focused on warrants (e.g., Sprenkle [1964], Samuelson [1965], McKean [1965], Chen [1970]), predominantly all recent work has been directed towards options. Unfortunately, some confusion has arisen over the distinction between options and warrants because of inconsistent terminology usage.

A warrant is a hybrid form of marketable security giving its owner the right to purchase a share(s) of stock at a given (exercise) price on (or before) a specified date. It is issued by a company (i.e., the firm, itself) and offers high leverage and limited liability (to the buyer). A call option[10] has the same (or similar)

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9 See Smith [1979] for a comprehensive review.

10 A firm does not issue a corollary to the put option. There is no analogous warrant-type security, issued by the firm, which gives its holder the right to sell a share of common stock.

terms as the warrant except that is is issued by a private individual in the market place, instead of a company. However, as Merton [1973] has noted, the principal difference between valuing the call option and warrant is that the aggregate supply of call options is zero, while the aggregate supply of warrants is generally positive. That is, when a call option is exercised, the issuer of the private, interpersonal contract goes to the stock market and buys existing shares at their prevailing price (or gives up shares currently held), and delivers them to the option holder. When warrants are exercised, the firm generally issues new shares. Consequently, the probability distribution of stock price returns is unaffected by the creation of these call options, but could be affected by the issuance of warrants. Put simply, options are exercised; warrants are converted. That is, a warrant holder can actively change his role in the managing of a firm. This possibility that new shares will be issued necessitates a captial structure adjustment to the OPM unique to warrants. In recognition of this possibility, the Accounting Principles Board, in Opinion #15, requires that a firm with warrants outstanding report dual earnings per share numbers so that financial statement users can visualize the potential "dilution" effect of exercise.

Warrants and the Firm

With respect to warrants, it is conceivable that the investment and financing decisions of a firm would not remain separate (or separable). The scenario can be hypothesized as follows: the firm issues warrants; the firm earns positive income; the firm announces a (relatively large) dividend; the warrant holders exercise their option, converting into common shares, immediately prior to the ex-dividend date; the firm issues the warrant holders new shares of common stock; the capital structure of the firm (including its D/E ratio) is affected; the dividend and capital structure decisions <u>interact</u>. This potential interaction surrounding the dilution of equity interests has had a large impact on the theory of the firm. Jensen and Meckling [1976], Smith and Warner [1979], Mikkelson [1980], among others have hypothesized that this conversion feature was created so as to reduce the agency cost of debt.

Supposedly, the management of a firm with straight debt outstanding will have an incentive to increase the risk of the firm, since downside risk is borne by the bondholders while the upside returns accrue solely to the stockholders (Brennan and Schwartz [1982; p. 36]).

Offering creditors a portion of high returns through either attaching warrants to the bonds or providing a convertible feature reduces management's incentive to substitute to higher variance investments. Viewing the shareholders as holding an option on the firm to buy out the bondholders, increasing the variance of returns would increase the shareholders' value, but with warrants or convertible bonds outstanding the returns would potentially have to be shared. That is, the higher the variability of returns, the higher the probability that the stock price will obtain a level which makes conversion of the warrant feasible. Brennan and Schwartz [1982] noted that by issuing a convertible rather than a straight bond, management reduces any incentive it would have had to increase the risk of the firm simply to expropriate the bondholders, because the convertible holders are protected against this type of expropriation by their conversion privilege.

However, these contingent securities might give management an incentive to expand dividend payouts to dampen stock price so as to reduce any wealth sharing with the contingent claim holders. When a call option is exercised, there is no capital structure effect, but with a warrant or convertible bond, there is. It might be argued, therefore, that, from an individual firm's point of view, the warrant could even be a more sensitive hybrid security than the option, in spite of its relatively longer useful life at issuance, and hence a better barometer of information content.

The warrant is often employed as a "sweetener" and comes attached to a public issuance of bonds or debt that is privately placed. Like the option, its value is <u>derived</u> in that it is contingent on a rise in the market price of the underlying stock. As a result, the issuing corporation should be able to obtain a lower interest rate on its accompanying debt instrument than it would otherwise. For companies deemed marginal credit risks, the use of warrants may make the difference between being able to raise external financing through a debt issue or not. Besides a sweetener, warrants are used in the founding of a company as compensation to underwriters and venture capitalists, or as an additional compensation factor (as per APB Opinion #25) to certain high ranking employees (termed compensatory or noncompensatory stock option plans).

Warrants may be either detachable or nondetachable. Obviously, only detachable (i.e., actively traded) warrants are of interest to this study. These may be sold separately from the bond; hence, their value as a "contingent claim" is a function of common stock price and volatility, not bond value (i.e., the bond-holder does not have to exercise his option in order to obtain the value of the warrant).

The exercise price of a warrant can be either fixed (which is most common) or "stepped up" over time. In addition, the warrant may specify the date on which the option expires[11] or have perpetual existence (i.e., no expiration date). Merton [1973], among others, has demonstrated that the price of a perpetual warrant (should) equal(s) the price of the underlying common stock if the option is dividend-protected (p. 145). Because the warrant is only an option to purchase stock, the warrant holder is not entitled to any cash dividends on the common stock nor does he have voting power. However, if the underlying stock is split or a stock dividend is declared, the option price of the warrant is usually[12] adjusted to take this change into account.

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11 Warrants generally have useful lives $\geq$ those of options.

12 Presuming there are no economies of scale (see Merton [1973; p. 152]), it is generally agreed that a stock split or a stock dividend will not affect the distribution of future per dollar returns on the common stock.

Finally, a firm cannot force the exercise of the warrant option as it can force the exercise of the conversion option by calling a convertible security. Consequently, an enterprise is unable to effectively control when the warrant will be exercised and when there will be an infusion of new equity capital into the corporation.[13]

Valuation of Warrants

Like an option, the <u>theoretical</u> value of a warrant (W) can be determined in an "ad hoc" fashion by (Van Horne [1980; p.643]):

$$W = N\,S_p - X$$

where N ≡ the number of shares that can be purchased with one warrant,

X ≡ the exercise price associated with the purchase of N shares,

S_p ≡ the market price of one share of stock.

For the valuation of a call option, N=1. At its expiration date, the value of warrant is simply the maximum of zero or N S_p - X.

For an example, on January 26, 1977, Molycorp Inc.'s common stock closed at $45.125 per share. The exercise price of the Molycorp warrants was $15.00, which enabled the holder to purchase <u>one</u> share of common stock for each warrant held. Van Horne's model would specify the theoretical value of the Molycorp warrant on that date was:

$$(1)(45.125) - 15.00 = 30.125$$

Although this warrant actually closed on that day at $29.25, most warrants sell at prices in excess of their theoretical values

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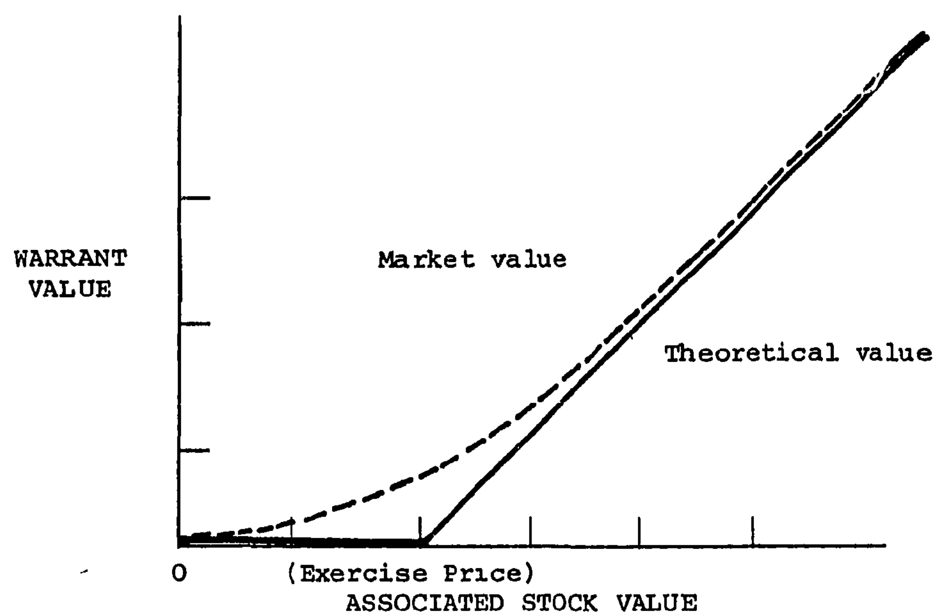
13 See Van Horne [1980; pp.641-644] for a thorough discussion of all these features.

(Van Horne [1980; p.643]). In general, three factors contribute to this premium: the variability (volatility) of the underlying common stock, the length of time to the expiration of the warrant, and the time value of money. In the Molycorp example, the warrant is "undervalued" in the market because it is relatively close to its expiration date. This undervaluation reflects the market's assessment of the probability that the warrant will go into the money before it expires.

Black and Scholes [1973] depicted the typical relationship between the market value of a warrant (where N=1) and the value of its underlying common stock as:



The theoretical value of the warrant is represented by the solid line, whereas the actual market value line is dashed.

Van Horne [1980, p.643] notes that when the market value of the associated stock is less than the exercise price, the theoretical value of the warrant is zero (it can never be negative because of its limited liability to the buyer). However, when the value of the underlying common stock is greater than the exercise price, the theoretical value of the warrant is positive (note, the line kinks and runs at a 45° angle starting from the exercise price).

Van Horne [1980] also points out that the shorter the length of time to the expiration of the option, the more <u>convex</u> the market value line. This implies that with only a few days to expiration, the market value line should asymptotically approach the theoretical value line. The same relationship also holds as the dividend on common stock increases. Because the investor in the warrant does <u>not</u> participate in the dividends paid on the common shares, the greater the dividend, the less attractive the warrant in relation to its associated stock. As a result, the greater the dividend, the more the actual value line would approach the theoretical value line (Van Horne [1980; p.644]). When a stock goes ex-dividend, the market price of the stock should drop by the amount of the dividend in the absence of taxes. The greater the present value of cash dividends to be paid prior to the warrant's expiration, the lower its value, all other things the same (Van Horne [1980; p.96]).

As Schwartz [1977] has noted, with an American option or a warrant, the presence of a cash dividend may affect the timing of when the option is exercised. He demonstrates numerically that there may be an incentive to exercise the warrant, converting to common shares, immediately before the ex-dividend date. The obvious advantage of this strategy to the warrant holder is receipt of the dividend. The disadvantage associated with early exercise of the warrant is the opportunity cost (at the risk free rate) on the interest that would have been earned on the exercise price. As a result, Schwartz [1977] points out that the optimal time to exercise involves a tradeoff between these factors.

Clearly, a warrant pricing model used for empirical tests of the information content of dividends must acknowledge this array of differences between the call option and the common stock warrant. Most notably, two of the features, the dividend and capital structure effects, are be explicitly accounted for in this study.

2.3 Adaptation of the Continuous (Black-Scholes) Model

Black and Scholes [1973] have developed a valuation formula for call option prices which, given their assumptions, depends upon only five variables (four of which are directly observable). [See Appendix A, Model #1.]

They provide the following functional form for the value of the (European) call option:

$$C = f(S,\ X,\ \sigma^2,\ T,\ r_f)$$

An intuitive interpretation may be provided for each of the partial derivates of the call price, C, with respect to its various arguments.

$\frac{\partial C}{\partial S} > 0$: The higher the value of the underlying stock, S, the greater the value of an option written on it. That is, the value of the call increases as a function of the value of the stock, for a given exercise price and maturity date.

$\frac{\partial C}{\partial X} < 0$: The lower the exercise price, the greater the value of the call option. That is, the less it costs to exercise the option, holding stock price constant, the more the option is worth.

$\frac{\partial C}{\partial \sigma^2} > 0$: The higher the instantaneous variance rate of return on the associated common stock, the greater the value of the option. That is, the more volatile the stock, the greater the probability that the stock will exceed the exercise price of the option before it expires.[14]

$\frac{\partial C}{\partial T} > 0$: The longer the time to maturity of the option, the greater the value of the option. That is, greater the length of time before the option expires, the greater the chance that the stock price will climb above its exercise price.

$\frac{\partial C}{\partial r_f} > 0$: The higher the risk free rate of interest, the greater the value of the option. Copeland and Weston [1979] explain:

> Black and Scholes [1973] have shown that it is possible to create a risk-free hedged position consisting of a long position in the stock and a short position (where the investor writes a call) on the option. This insight allows them to argue that the rate of return on the equity in the hedged position is <u>nonstochastic</u>. Therefore the appropriate rate is the risk-free rate, and as it increases, so does the rate of return on the hedged position. This implies that the value of the call option will increase as a function of the risk-free rate of return. [p.377]

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14 Copeland and Weston [1979; p.376] provide a good intuitive example of this point.

These comparative statics provide an insight into complex equilibrium relationship characterized by the OPM. This insight can also be enhanced by considering the concept of a <u>hedge ratio</u>.

Since trading is assumed to be <u>continuous</u>, it is possible to create a hedged portfolio that is "risk free" by combining a long position in the stock with a short position in the call option in the appropriate proportion. This hedged (riskless) position is accomplished by undertaking a trading strategy which <u>continuously</u> maintains the "hedge ratio."[15] This ratio is shown to be the inverse of the partial derivative of the option pricing formula with respect to its first argument (stock price) [p. 641]. It is represented by the (inverse of the) change in option price (C) relative to the change in stock price (S). This formulation provides the Black-Scholes hedge ratio of: (p. 645)

$$\left(\frac{\partial C}{\partial S}\right)^{-1} = N(d_1)^{-1} = \frac{1}{N(d_1)}$$

This strategy stipulates the number of options that must be sold short[16] against one share of stock held long. By <u>continuously</u>

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15 Although the hedge ratio, per se, does not explicitly surface in the empirical tests of the information content of dividends, it is still a drastically important concept. The assumption regarding an investor's ability to maintain that hedge is what differentiates the two versions of the OPM employed in this study.

16 Conveniently, to indicate a short position in the option the following negative sign can be added: $\left(\frac{\partial C}{\partial S}\right)^{-1} = -\left[N(d_1)\right]^{-1}$. This notation will surface again in Appendix D.

adjusting one's position, risk-free portfolios (of hedges) are created which eliminate the effect of stock price movements. Even though with transaction costs it is impossible to continuously adjust the option position, Black and Scholes [1973] argue that the risk that will appear as a result of moderate changes in stock price or of the passage of time will generally be small (immaterial) and can be diversified away.

A Dividend Adjustment

When deriving the value of an option, Black and Scholes [1973] made several restrictive assumptions. Since its original introduction, their model has been considerably generalized and certain of their assumptions have been relaxed.

Concerning the Black-Scholes (B-S) assumptions:

(1) The stock pays no dividends or other distributions; and
(2) The option can only be exercised at maturity (i.e., it is "European"),

Roll [1977] has observed, the unprotected "American"[17] call option written against a dividend-paying stock is the predominant, actively traded option in the market. In general, on the CBOE as well as the NYSE and ASE, call options and warrants have no contracted "protection" against the (probable) stock price decline that occurs when a dividend is paid. This precipitous drop in stock price on the ex-dividend date would distort the equilibrium pricing relationship

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17 An American-type call option may be exercised any time prior to expiration.

between the stock and option (or warrant) written against that stock. Moreover, because warrants have longer useful lives than options, there is some positive (nontrivial) probability that the underlying stock will pay a dividend. Thus Roll points out an important deficiency in option pricing theory in terms of its empirical applicability. It is therefore necessary to institute some formal acknowledgement of dividends into the model.

Black [1975], Patell and Wolfson [1979a, 1979b, 1981], Roll [1977] and Geske [1979] have all noted various adjustments to the (Black-Scholes) option pricing formula that would allow the firm to pay dividends.

In somewhat of a practitioner-oriented article, Black [1975] suggested an ad hoc approach to call option valuation when the underlying stock pays dividends during the life of the option.

> If the option will be exercised <u>only</u> at maturity, we can approximate the value of the option on a dividend paying stock by substracting the present value of the dividends likely to be paid before maturity from the stock price. We use this adjusted stock price instead of the actual stock price in the option formula. (p. 4)

It is clear that an option on a stock that pays a dividend is worth less than an option on an identical stock that pays no dividend, ipso facto (i.e., $\partial C/\partial S>0$). Correspondingly, the larger the dividend, the less the option is worth. This phenomenum occurs because when a stock goes ex-dividend, the stock price usually falls, necessarily reducing the likelihood that the stock will be able to climb above its exercise price by maturity (hence the option expires worthless) (Black [1975; p. 41]).

Patell and Wolfson [1979] take note of two potential problems when this type of dividend adjustment is empirically implemented into the option pricing model: (pp. 132-133)

(1) When actual dividends paid during the life of the option are substituted into this approach for expected dividends (like Merton, Scholes, and Gladstein [1978] did), the adjustment implicity assumes that the dividends paid are escrowed at the date on which the stock price is observed. To the extent that the future dividend is uncertain in amount, this DCF approach is not completely satisfactory.

(2) For whatever market reasons (exogenous to the model), the stock price may not decline by an amount equal to 100% of the dividend at the ex-dividend date (see Roll [1977] and Geske [1979]'s α adjustment factor which incorporates tax effects into the model).

An additional problem arises when the option may be exercised any time prior to the expiration date (i.e., an "American" option). As Merton [1973] demonstrated, when the underlying stock pays a dividend there is a positive probability (although small) that the option will be exercised early. Roll [1977; pp. 252-253] noted that early exercise is more likely the larger the dividend, the higher the stock price relative to the exercise price (i.e., the more "deeply-in-the-money" the option), and the shorter the time period between expiration and dividend payment dates. In his review article, Smith [1976] demonstrates this same point via his dominance arguments. Patell and Wolfson point out that premature exercise will only be optimal, if ever, immediately before the underlying stock goes ex-dividend (p. 134). Correspondingly, an alternative procedure must be employed to deal with the possibility of early exercise. Black [1975; pp. 41, 61, and 72] suggests a second method which involves making two calculations of the option's value and using the one that generates the higher value (see Patell and Wolfson [1979; p. 134]). Patell and Wolfson (pp. 134-135) demonstrate that this procedure implies that a maturity date (i.e., the correct exercise date) should be selected for their calculations which yields the lowest implied variance.

MacBeth and Merville [1979; p. 1181] assumed the option would be exercised just prior to the ex-dividend date and computed an implied variance rate. They invariably obtained a value larger than the implied variance rate that was originally calculated. Since they found no evidence of an early exercise effect on the prices of options with between ninety and one hundred days to expiration, they concluded it was appropriate to assume their modeling procedure was not contaminated by an early exercise effect. Unfortunately, this procedure suffers from the same implementation weaknesses cited earlier; therefore an alternative dividend adjustment is preferred.

Roll [1977; p. 252] assumed that the American call option was written on a stock with one known dividend that was certain to be paid, allowing him to specify that the stock price (i.e., market value less discounted escrowed dividend) would still follow a lognormal process. He was therefore able to derive an exact analytic solution to the option valuation equation, subject to his boundary conditions, that explicitly considered dividends. His approach shows that simple options can be used to span the set of states relevant to the more complex valuation problem (i.e., considering dividends), by creating a portfolio that duplicates the (combined) relevant cash flows. Roll's equation essentially results from combining formulas for three independent European options.

Geske [1979; p. 376] noted that this formulation of the American call on a dividend-paying stock was in essence "an option on an option" (i.e., a compound option) and unnecessarily complex. He was able to provide a less complicated analytical solution to the single dividend case as well as an extension that could be generalized to the case of "n" dividends.

In an information-content-of-dividends study, the dividend adjustment incorporated into the OPM is not a trivial consideration. Unfortunately, the utility of these types of adjustments is predicated on the ability of market agents to *continuously* form a risk-free hedge. While consistent with the trading behavior assumed by Black-Scholes (i.e., in the continuous version of the OPM), these adjustment mechanisms would violate the basic assumption of the *discrete* version of the OPM developed by Lee, Rao, and Auchmuty (LRA) [1981] which is also employed here. Correspondingly, to incorporate a single adjustment in both versions of the model, a different mechanism is used. In addition, the adjustment incorporated here has the added advantage that it is forward-looking. This is compatible with the ex-ante methodology which focuses on investors' *anticipation* of the dividend announcement.

Merton [1973; p. 171] has suggested such an adjustment which, although originally presented for the B-S version, can be readily adapted to the LRA discrete model. He hypothesizes a specific dividend policy where dividends are assumed to be paid continuously such that their yield is constant. Although this assumption does not conform to actual dividend policies of firms, it can be argued that it represents the exogenous (i.e., observable) counterpart of managements' attempt to maintain a target payout ratio. In order to implement Merton's adjustment into the B-S model, it is necessary to convert discrete payments to an equivalent continuous rate. Even though dividend payments are obviously not made at a continuous rate, it might be argued that the distributable income (which generates the cash which facilitates the payment) accrues over time and thus Merton's adjustment is acceptable as a first approximation.[18] Allowing for a constant, known, continuous dividend yield (y) on the underlying common stock, generates a slightly modified form of the valuation equation[19] [see Appendix A, Model #2].

This version of the OPM was employed by Chiras and Manaster [1978] in their predictive ability and market efficiency tests.

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18 Conversion of discrete dividend payments into a continuous yield dividend rate should not be confused with the discrete versus continuous trading controversy surrounding the option pricing model itself; they are unrelated considerations.

19 This equation differs slightly from that reported in Merton [1973; p. 171, footnote 62] but agrees with the solution, referenced by Merton, of Samuelson [1965] and the solution reported in Smith [1976; p. 26].

The Capital Structure Adjustment

A second adjustment must be made to the call option pricing model to accomodate the potential capital structure effect (i.e., dilution) the exercise of warrants can have. This constitutes a critical theoretical difference which must be accounted for in an empirical test. Consequently, to account for the additional common shares that will be issued if warrants are exercised, a second adjustment, α , must be incorporated into the model to characterize this potential dilution of equity interests.[20]

These two modifications taken together lead to one of the two versions of the "warrant pricing model" (WPM) which is employed in this study:

(a) Warrant Pricing Model #1:

$$W_i = e^{-yt} \cdot \alpha V_i \cdot N\{d_1\} - (1-\alpha) X^N \cdot e^{-r_f T} \cdot N\{d_2\} \qquad \text{where,}$$

$$d_1 = \frac{\ln\left[\frac{\alpha V_i}{(1-\alpha) X^N}\right] + \left(r_f - y + \frac{1}{2}\sigma^2\right)T}{(\sigma\sqrt{T})}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

with $W \equiv$ The price (value) of the total warrant issue (i.e., $Q_W \cdot w_i$)

$w_i \equiv$ Warrant price for a single share of stock (i.e., the current warrant value)

$\alpha \equiv Q_W/(Q_W+Q_S)$ where Q_W is the number of shares sold through the warrant issue and Q_S is the number of shares currently existing in the market prior to exercise.

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20 This procedure was suggested by Smith [1979].

$V \equiv$ The total value of the firm's assets (i.e., $Q_S \cdot S_i$).

$X^N \equiv$ The total proceeds if all the warrants are exercised (i.e., $Q_S \cdot X_i$).

All other notation remains the same as before. [See Appendix A.]

(b) Assumptions are the same as OPM #2 (Appendix A) except:
(1) No other capital structure change will occur between the announcement date and the warrant's expiration date. That is, the firm will not issue any other debt or equity securities during the period being investigated.

(c) Beta:

$$\beta_c = \{\frac{\alpha V}{W}\} e^{-yT} N(d_1)\}\beta_i$$

(d) Hedge Ratio:

$$(\frac{\partial W}{\partial \alpha V})^{-1} = (\frac{\overline{Q}_W}{\overline{\alpha} \cdot \overline{Q}_S}[\frac{\partial w_i}{\partial S_i}])^{-1} = \frac{e^{yT}}{N(d_1)}$$

Note: The quantity of warrants ($\overline{Q}_W$), quantity of stock ($\overline{Q}_S$) and their ratio $\overline{\alpha}$ are fixed per firm per time period studied and become constants. Thus, they do not affect the change in warrant price relative to the change in stock price.

2.4 Evolution of the Discrete (Lee, Rao, Anchmuty) Model

A second version of the OPM is also employed. The alleged advantage (or at least difference) of this model is that because it does not analytically force a risk neutral valuation relationship to obtain, it allows expectations to surface in the pricing formula. Mechanically, this occurs because the Black-Scholes hedge ratio can be maintained continuously; that is, at each stock price movement, the stock's position in the portfolio is adjusted. If this hedging strategy can only be enacted at certain discrete points in time, risk associated with expected stock price movements will surface in the pricing relation. The expected return of a discrete hedging strategy will not be the riskless rate. In order to emphasize the significance of this distinction, it is insightful to trace the evolution of the Lee, Rao, Auchmuty [1981] version of the OPM.

A (call) option possesses all the essential features of a "contingent claim." Brennan [1979] defines a contingent claim as an asset whose payoff depends upon the value of another "underlying" asset, the value of which is exogenously determined. Clearly, what is needed is a valuation relationship (formula) that will relate the value of the contingent claim (or its derivatives) to the value of the underlying asset and/or other exogenous parameters (which can be observed). Unfortunately, as Merton has observed [1973]:

> (A)n exact formula for an asset price, based on observable variables only, is a rare finding in a general equilibrium model. (p. 161)

However, as Brennan [1979] points out, a risk neutral valuation relationship (RNVR) only depends upon potentially observable parameters and it is extremely significant that such a relationship can be derived from only "weak assumptions" about investor preferences (i.e., their utility functions) (p. 53).

Historically, RNVR's have been derived from two quite different general classes of models:

(1) Models in which no restriction is placed on investor preferences beyond the assumption of nonsatiation (i.e., more wealth is better than less), but they assume trading takes place continuously.

(2) Models which place stronger restrictions on investor preferences, but, make the more general assumption that asset trading takes place at discrete time intervals.

These two mutually exclusive classes of models are examined independently. As Black and Scholes [1973] demonstrate, in the absence of riskless arbitrage opportunities, if trading takes place continuously and both the underlying asset (stock) and the contingent claim[21] are traded assets and at least one of them is infinitely divisible (scaling problem), then the price dynamics of the underlying asset can be described by an Itô process. As Brennan [1979] comments:

> (T)his no arbitrage condition (see Merton [1973; p. 143] for a comprehensive definition) can be shown to imply a partial differential equation (adapted by Black and Scholes from the heat transfer equation in physics) relating the value of the contingent claim to the value of the underlying asset, and this partial differential equation does not involve investor preferences.

Black and Scholes (p. 644) also point out that the equation does not depend on the expected return of the stock; that is, the option value, as defined, is a function of the stock price observed and thus independent of any expectations. Hence Brennan observes the solution to this differential equation is also preference free and therefore provides a valuation relationship which is consistent with risk neutral preferences (i.e., a RNVR) (p. 54). This is consistent with Black and Scholes' observation that, in equilibrium, the expected

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21 Specifically, a dividend protected, European call option.

return on such a hedged (risk neutral) position must be equal to the return on the riskless asset (r_f) (p.640). This prompts Lee, Rao, and Auchmuty [1981] to comment:

> (I)f the hedge is maintained continuously however, then the approximations become exact and the portfolio is risk-free overtime. That is, by continuous revision, the portfolio return becomes independent of the stock price behavior. In fact, as Black and Scholes argue, the entire systematic risk of the portfolio is unaffected by the vagaries of the market portfolio, i.e., there is no market risk. (p. 77)

In an analogous context, Cox and Ross [1976] have argued that whenever a portfolio can be constructed which includes the contingent claim (option) and the underlying asset (stock) in such proportions that the instantaneous return on the portfolio is non-stochastic, the resulting valuation is risk neutral.

Lee, Rao, and Auchmuty [1981] comment that hedging in continuous markets permits treatment of the economy as if it were risk neutral. This explains why the expected rate of return on the stock and the market risk considerations do not enter the Black-Scholes analysis (p. 79).

Brennan warns, however, that in a model in which trading takes place only at discrete time intervals, it is generally not possible to construct a portfolio (i.e., a continuous hedge) that contains the contingent claim and the underlying asset in such proportions that the resulting portfolio return is non-stochastic (and hence, risk neutral) (p. 54). Brennan's observation suggests the following two ramifications:

(1) It is no longer possible to form a risk free hedge.

(2) It may not be possible to derive a valuation formula that is independent of expectations.

Merton [1973] has demonstrated analytically that the Black-Scholes model will still obtain with discrete trading providing the following conditions are still satisfied:

(1) There is a single investor whose utility function exhibits constant proportional risk aversion (CPRA);
(2) Returns on the underlying asset follow a lognormal distribution; and
(3) The underlying asset is "aggregate net wealth."

In a more recent paper, Rubinstein [1976] extends Merton's analysis by relaxing his assumptions to include:

(1) Conditions of aggregation are satisfied so that it is appropriate to speak of a representative individual;
(2) The representative individual has a utility function which exhibits CPRA; and
(3) The returns on the underlying stock and rate of growth of aggregate consumption are (arbitrarily) bivariate lognormally distributed.

At each iteration the assumptions governing the operation of the OPM have become less restrictive. Brennan delineates the three primary advantages to adopting a discrete time version of the option model: first, it has greater generality; second, it places <u>no</u> restriction on the stochastic return generating process of the underlying asset and it allows both the stock and the option to be purchased or sold in any proportion; and finally, it permits the introduction of heterogeneous probability assessments across investors and even individual uncertainty as to the parameters of the underlying probability distributions (pp. 54-55). Contrast this with the continuous model which assumes the parameters of the underlying stochastic process are known with certainty and agreed upon by all investors (i.e., deterministic). Necessarily, the relaxation of certain assumptions imposes additional measurement difficulties for the new parameters. That is, there is a trade-off between model generality and empirical tractability.

Brennan then confirms Rubinstein's criteria by demonstrating that constant proportional risk aversion (CPRA) is both a necessary and sufficient condition for RNVR's to obtain when the underlying asset return and market return are bivariate log-normal.

Finally, Lee, Rao, and Auchunty [1981] extend Brennan and Rubinstein's criteria one step further by relaxing the requirement that risk neutrality be established. Bawa [1975] points out:

> (S)ince decision-making under uncertainty may be viewed as choices between alternative probability distributions of returns in accordance with a consistent set of preferences, the more restrictions imposed on utility functions, the smaller will be the admissible set, leading to a concomitant loss of generality. (pp. 95-96)

Lee, Rao, and Auchmuty [1981] were able to derive a general equilibrium call option pricing relation under the assumption that investors trade at finite (i.e., discreet) time intervals. In addition, their framework does not require a representative individual and it does not restrict each individual to a CPRA utility function. They merely specify that individuals must exhibit increasing, concave utility functions, with positive skewness (i.e., positive third derivatives). Note, this characterization of investor preferences is consistent with the set of <u>decreasing</u> absolute risk aversion (ARA) utility functions which contains the group of CPRA functions as a proper subset. Because their model does not require continuous trading or restrict analysis to a set of investors who have constant proportional risk aversion (CPRA) utility functions, a risk neutral valuation relationship (RNVR) will not obtain. In fact, the risk involved in holding an option will be priced and the relevant risk is the systematic risk of the option. [See Appendix B for an analytical comparison of Betas.]

In an empirical test of the Black-Scholes option pricing relation, Galai [1975] using Scholes' (unpublished) estimate for the variances and ignoring transaction costs, found above-normal profits could be earned on hedges of CBOE options and underlying stock; his results indicate either that the hedges were not riskfree because the model used to determine the hedge ratios is incorrect or that the market misprices options (Johnson [1979; p. 2]).

In an analogous context, Latané and Rendleman [1976] noted: (paraphrased)

> Expected returns from the underlying stock do not enter the Black and Scholes model. However, this does not imply that expected returns are not a factor in the market. To the extent that transaction costs, margin requirements, and a lack of a well developed put market prohibit continuous portfolio rebalancing and the exploitation of arbitrage opportunities involving puts and calls, it is possible that option prices are partially determined by investors or speculators who do not hedge or continuously rebalance their portfolios ... The mathematics of the B-S model imply that any increase in an option's value which is caused by an increase in the expected return from the underlying stock is offset by an increase in the option's required rate of return. However, if investors do not increase the required rate of return on the option by the amount which is implied by the B-S model, then the option's price will be affected by changes in return expectations. (p. 380)

It is apparent that the B-S version of the OPM at times systematically misprices options. It can be inferred from these results that an OPM that facilitates a hedging strategy based on expected stock price movements might improve the model's performance. LRA [1981] have developed such a version of the OPM which impounds the aggregate market's expectations [see Appendix A, Model #3].

This call option valuation equation reveals that the option price (C) is dependent upon market effects through the expected logarithmic return on the underlying asset, μ_i, and its logarithmic covariance with the market return, σ_{im} (LRA [1981; p. 15]).

Their extension is not costless; it adds two more potential sources of measurement error. However, the purpose of this study is not to compare the predictive ability of one OPM vis-à-vis another. Rather, the two OPM formulations used in this analysis provide a compatible means to calculate the variable of interest -- the implied standard deviations of firms' common stock. Also, the empirical implementation of both models is very similar even though they have different theoretical origins.

Black and Scholes [1973] were able to derive their option pricing relation by means of two independent arguments. One derivation rested on the assumption that investors can create riskless hedges between options and stocks. Their alternative derivation was founded on the CAPM. Although they did not explicitly make the assumption that investors continuously rebalance their portfolios in this version of the proof, such behavior was implied if investors' attitudes toward risk are to remain constant through the duration of the option contract. Whether investors choose a portfolio with no risk or attempt to maintain a desired "beta" level, an option investment must be continuously rebalanced among stock and/or a riskless security in order to hold the risk characteristics of the portfolio constant through time (Latané and Rendleman [1976; p. 380]).

In an analogous context, the Rubinstein-Brennan analysis, because of its restrictive assumptions, also forces a risk-neutral valuation relationship to obtain (i.e., the systematic risk of the call option goes to zero). LRA, however, have explictly provided for the market effects to be impounded in their call option price. In this regard, they observe that their valuation formula should contain the B-S version as a special case (p. 87). The significance of this distinction can be most readily observed by comparing betas generated by each model.[22]

A final result of LRA's simulations (results 3, 4, and 5) is particularly relevant to this study: because they explicitly give recognition to the systematic risk of the option (which Black and Scholes price at zero), the appropriate hedge ratios for the B-S model and theirs should be different. [See Appendix A] They note:

> The difference in magnitude of the systematic risk of the call option between the B-S model and ours results in a difference in magnitude of the appropriate hedge ratios ... The magnitude of difterence in the prices provided by the two models will be most dramatic when the difference in the

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22 See Appendix B.

> hedge ratios is most significant. This will occur when the option is sufficiently in- or sufficiently out-of-the-money. (p. 95)

One problem Patell and Wolfson [1979] acknowledged in the empirical implementation of the B-S formula was:

> (I)n addition to the noise that this problem introduces into the tests, the non-synchronous trading problem also leads to an upward bias in the computation of implied standard deviations. This bias can be shown to increase for deep in-the-money options. (p. 135)

Because of the institutional idiosyncrasies[23] associated with warrants, this potential source of measurement error should not be ignored. Hopefully, the LRA version can reduce (or smooth out) at least part of the bias.

Adjustments to the Discrete Model

As with the B-S model, Merton's dividend adjustment and Smith's capital structure adjustment must be incorporated into the LRA model before it can be used to price warrants. The imposition of these adjustments does not substantially interfere with the text of the solution (i.e., the stochastic calculus), it merely imposes two additional scaling parameters. [The algebra required for the adaptation is presented in Appendix C.]

These two modifications taken together lead to the second version of the warrant pricing model which is employed in this study:

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23 That is, longer useful lives, interday, non-synchronous trading behavior, or commonly trading in excess of their theoretical prices.

(a) Warrant Pricing Model #2:

$$W_i = \exp(-yT)\alpha V_i[1-\theta]N(d_1^*) - (1-\alpha)X^N \exp(-r_f T)N(d_2^*)$$

$$\text{where } \theta = \frac{\exp(\mu_i T) - \exp(r_f T)}{\exp(r_f T)} \; \Phi$$

$$\text{and } \Phi = \frac{[N(d_3^*) - N(d_1^*)] \exp(\sigma_{im} T) + N(d_2^*) - N(d_4^*)}{N(d_1^*)[\exp(\sigma_{im} T) - 1]}$$

$$\text{with } d_1^* = (\sigma_i\sqrt{T})^{-1} [\ln(\frac{\alpha V_i}{(1-\alpha)X^N}) + (\mu_i - y + \frac{1}{2}\sigma_i^2)T]$$

$$d_2^* = d_1^* - \sigma_i\sqrt{T}$$

$$d_3^* = (\sigma_i\sqrt{T})^{-1} [\ln(\frac{\alpha V_i}{(1-\alpha)X^N}) + (\mu_i - y + \frac{1}{2}\sigma_i^2 + \sigma_{im})T]$$

$$d_4^* = d_3^* - \sigma_i\sqrt{T}$$

All notation is the same as WPM #1.

(b) Assumptions are the same as OPM #3 (Appendix A). They also include the capital structure assumption (1) from WPM #1.

(c) Beta:

$$\beta_c = \{[\frac{\alpha V}{W}] \; e^{-yT} N(d_1^*)\}(1+ \Phi)\beta_i$$

(d) Hedge Ratio:[24]

$$(\frac{\partial W}{\partial \alpha V})^{-1} = \{(\frac{\overline{Q}_w}{\alpha \cdot Q_S})[\frac{\partial w_i}{\partial S_i}]\}^{-1} = \frac{e^{yT}}{[N(d_1^*)(1+\Phi)]}$$

[24] See Appendix D for algebraic derivation.

Summary

This chapter has provided the background, evolution, and extensions of the OPM's used herein to empirically test the information-content-of-dividends hypothesis. The OPM characterizes an equilibrium relationship between a contingent claim and its underlying asset. This pricing relation can be conveniently adjusted to accommodate certain contractual features unique to common stock warrants. Two versions of the WPM were developed that will provide time-series estimates of the underlying common stock's implied variability. Chapter 3 reviews the methodological procedures that are employed to operationalize the models. In Chapter 4, hypotheses concerning this implied variability are developed and tested.

CHAPTER 3

RESEARCH DESIGN METHODOLOGY

The purpose of this chapter is to specify the methodological procedures that are employed to facilitate tests of the information-content-of-dividends hypothesis. The chapter is organized as follows: section one reviews the sample selection procedures. Section two provides a discussion of the techniques used to estimate the parameters necessary to conduct empirical tests on the WPM's. Section three provides an overview of the Patell-Wolfson testing methodology. In the fourth section the concept of an implied standard deviation is introduced and its empirical implementation is described. Finally, section five discusses the relationship of firm size to stock variability and delineates some testable implications of the warrant pricing model.

3.1 Sample Selection Procedures

To examine the time-series behavior of the implied standard deviations generated from the equilibrium option pricing formula a sample of outstanding warrants was collected. The sample included every actively traded warrant[25] listed in Standard & Poor's Daily Stock Price Record (NYSE, ASE, OTC) that met the following criteria:

(i) The warrant must have expired between January 1, 1976 and December 31, 1981 (6 year period) inclusive.

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25 See Appendix E for a complete listing of firms.

(ii) The warrant must have had a fixed exercise price and conversion ratio.

(iii) The warrant must have had a specified expiration date (i.e., perpetual warrants were excluded, e.g. Alleghany Corp. or Commonwealth Edison).

(iv) The warrant must have been convertible into shares of common stock (i.e., not preferred stock, e.g. Kidde Inc. or Talley Industries Inc.).

(v) The warrant must have been actively traded on either the New York or American Stock Exchange or Over The Counter.

This restrictive set of criteria was necessary to insure that the final sample contained all the parameters necessary for implementation into the WPM's. For each remaining warrant meeting these criteria, a dividend history of the corresponding firm's common stock was compiled. These histories were then evaluated to insure they were sufficiently comprehensive to justify examination of the information content issue. For a five year period preceding the expiration date of the respective warrant, dividend announcement dates and amounts, adjusted for stock splits, were obtained from Moody's Dividend Record and independently verified in the Wall Street Journal Index. To avoid the confounding effect of synchronous signals, quarterly earnings announcements were also recorded for the final year prior to warrant expiration. Any firm for which the dividend and earnings announcement dates coincided or sample periods overlapped was eliminated. Each sample period was also examined for any other type of firm-specific information event or announcement that might have contaminated this dividend study. Of the more than 100 actively traded warrants that started in the sample, these criteria reduced the final sample size to 40.

3.2 Estimation of Parameters

MacBeth and Merville [1979] observed that the discrepancy between actual and theoretical option prices tends to be more pronounced (irrespective of the relationship between S and $X \cdot \exp[r_f T]$) the farther the option is from expiration. This observation is intuitively consistent with one's expectations because B-S model prices and the market prices should converge to a maximum of zero or S-X as the option approaches its expiration date (Smith [1976; p.7]). Patell and Wolfson [1979] noted that the magnitude of effect (i.e., the height and steepness of the variance profile) increases as the expiration date of the option is moved closer to the disclosure period (p. 121). They observed that if two call options are identical in all respects except expiration date, and both terms to expiration include a single anticipated information disclosure: (pp. 122-123)

(1) The average variance implied by the price of the shorter option will exceed that implied by the simultaneous price of the longer option on dates preceding the information disclosure date.

(2) The rise and subsequent decline of the average variance implied by the longer option's prices will be less extreme than that implied by the shorter option's prices.

Because of the model's sensitivity to this time-to-expiration parameter (T), this study evaluates at most the two final dividend announcements prior to the expiration date of the warrant. To determine time-to-expiration, calendar days to maturity (CDTM) were calculated by counting the number of days from each individual dividend announcement date to the date the warrant expired.

For each warrant basic background data (i.e., the exercise date, exercise price, conversion ratio, quantity of common shares outstanding and quantity of warrants outstanding (translated into its common stock equivalent)) were collected from Moody's Manuals. These data were confirmed in the C & P Warrant Analysis Guide and the Daily Stock Price Record.

Daily warrant and common stock prices were obtained for each sample period from the Daily Stock Price Record. These sample periods were 30 trading days long surrounding the actual announcement date; 24 days prior to the day itself, the day, and the 5 following days. Some warrants were convertible into more (or less) than one share of common stock. To adjust for a conversion ratio other than 1:1, the daily warrant price was divided by its respective conversion ratio to obtain the adjusted warrant price used in the model.

The firm's market value was calculated by multiplying the number of shares of common stock outstanding times a 200 day moving average stock price[26] immediately prior to the announcement date closest to maturity. This statistic is used in the large/small firm dichotomy.

To approximate the risk free rate of interest (r_f), the Treasury Bill rate whose term to maturity was closest to time to expiration was used. The rates selected correspond to the weekly T-Bill rate quoted in the Federal Reserve Bulletin in effect on or immediately before each specific dividend announcement date.

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26 A 200 day moving average stock price was employed to lend some intertemporal stability to this size measure.

Existing, and thus currently traded T-Bills (i.e., not new issues) were used. So as to more closely approximate the time remaining to maturity for each announcement date, the following convention was employed. If CDTM $\leq$ 125, a 3 month rate was used; if 125 < CDTM $\leq$ 275, a 6 month rate was used; and if CDTM > 275 a one year rate was used. To convert the Federal Reserve's bank discount rate (I_{B-D}) to the true (real) discount rate (I_T) needed in the model, the following algorithm was employed:

$$\left[\frac{I_{B-D}/n}{1-\left(I_{B-D}/n\right)}\right]\cdot n = \frac{I_{B-D}}{1-\left(I_{B-D}/n\right)} = I_T$$

where n ≡ the number of periods for which compounding occurs (i.e., for a 3 month rate, n=4; for a 6 month rate, n=2, etc.).

This method of estimating the risk free rates in option pricing studies is reasonably common (see for example, Chiras and Manaster [1978], or MacBeth and Merville [1979]). Its comparative advantage is that rather than using an exact rate which fluctuates daily, it specifies the risk free rate at some average, estimated at the beginning of the relevant time interval, that remains constant over the entire test period.

Finally, the μ_i and σ_{im} parameters introduced in the discrete version of the option pricing model (WPM #2) were estimated by using 5 years of monthly return data (60 months) prior to each announcement date.[27] These logarithmic parameters were calculated as follows:

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27 Consequently for WPM #2, 4 firms which were traded OTC and for which monthly stock returns were not readily available, were dropped. All empirical tests of WPM #2 are conducted on 36 firms.

$$\mu_i = \frac{\sum \ln(1+R_i)}{N}$$

$$\sigma_i^2 = \frac{\sum[\ln(1+R_i) - \mu_i]^2}{N - 1}$$

and $$\sigma_{im} = \frac{\sum[\ln(1+R_i) - \mu_i][\ln(1+R_m) - \mu_m]}{N - 1}$$

where N ≡ number of months (=60) prior to the respective announcement date.

Of the regular WPM parameters, only warrant price, stock price, and time to maturity change daily. The remainder of these parameter values (including μ_i and σ_{im}) are assumed to be fixed over the entire sample period.

3.3 Review of the Patell-Wolfson (ISD) Methodology

Patell and Wolfson [1979] employed a methodology that was designed to test for changes in the implied variance of common stock returns. They observe that this differs from previous security price accounting research which has focused primarily on changes in mean returns to detect information content (p. 118).

They postulate a simple model of the variance profile in which the underlying asset's (stock's) variance is expected to increase during periods of information disclosure. Theoretically, the justification for this hypothesized profile is as follows:[28] if it is publicly known in advance that a major accounting information release will be made at a specific point in time, even though the content of

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28 See also Beaver [1968] and Ohlson [1979].

the disclosure itself is unknown, one could anticipate increased variance during the period immediately surrounding the disclosure date (p. 120). The equilibrium status of the market is temporarily upset as market participants receive, interpret, and react to various dividend-related cues in anticipation of the dividend announcement. A stock's variability (as well as its trading volume) tends to reflect a lack of consensus (uncertainty) among market participants as to the meaning of the about-to-be-released disclosure. Patell and Wolfson assert that once disclosure is made and its effects, if any, are assimilated into the security price, the average variance (technically, the expected average variance to expiration) drops to its "normal" level. Further, they specify that the sequence of prices preceding the information event should imply increasing expected average variance, while those after the announcement would imply a reduced average variance, with the largest (and therefore perhaps the easiest to detect) change occuring at the disclosure date itself (pp. 120-121).

To test the significance of changes in this average-variance-to-expiration statistic, ex-ante test procedures were developed by Patell and Wolfson [1979]. Implied average variances, generated via the option pricing model, were estimated at various points preceding and immediately following the annual earnings announcement, and their differences were examined for statistical significance. This measure of differences over time is defined as: (p. 124)

$$Z_{ab} = \bar{\sigma}^2(t_b) - \bar{\sigma}^2(t_a)$$

Where t_b occurs chronologically after t_a (i.e., closer to, but before, expiration).

In order to examine the time series behavior of any sequential pair of ISD's, Patell and Wolfson performed two <u>nonparametric</u> tests of significance on the Z_{ab}'s: the Fisher signs test and the Wilcoxon signed ranks test. Both tests model the process generating the successive differences in average variance to expiration as: (p. 125)

$$\tilde{Z}_{ab} = \theta + \tilde{\varepsilon}_{ij}$$

They point out that both tests assume that the error terms ($\tilde{\varepsilon}_{ij}$'s) are independent across firms and that each is drawn from a continuous population (not necessarily the same one for each firm) with median (of the ε distribution) equal to zero (p. 125). In addition, the Wilcoxon test further assumes that this distribution is symmetric.

Having modeled this variance generating process, per firm over time, Patell and Wolfson stipulate the following null hypothesis: (p. 125)

$$H_0: \theta = 0$$

They hypothesized there were no differences in the ISD's leading up to and passing through the earnings announcement. Depending on the time points selected for t_a and t_b it was appropriate to specify a one-sided (i.e., directional) significance test for the alternative hypothesis. They found that prices of options with <u>short</u> periods to expiration apparently reflect the anticipation of a temporary increase in stock price variability due to the expected release of annual earnings numbers (p. 137). They note:

> This anticipation is evidenced by steadily increasing implied average standard deviations from four weeks prior to the announcement date to the date of the announcement, and a dramatic decline in implied average standard deviations in the two-day announcement period. (p. 137)

This study models the time-series process in a similar fashion but employs parametric tests (t-tests and ANOVA) to examine the properties of regime-specific means.

3.4 The Implied Standard Deviation

Ohlson [1979] notes:

> A change in the disclosure environment of a firm constitutes a change in the state description; it follows that the value of a firm will not be the same at all points in time in two alternative disclosure environments. (The concept of 'disclosure environments' should be interpreted in very general terms; it encompasses such matters as frequency of financial reports, the provision for supplementary data, description of accounting policies, etc.) In other words, asset valuation depends on the information that is available; any change in this should, therefore, affect current and future prices. Furthermore, if future prices are sensitive to future disclosures, then the current price may depend on future disclosure policies even though the current information is the same. The latter must be viewed as a possibility since the current price depends upon the stochastic behavior of future prices (via investors' demand functions). (p.212)

The methodology developed by Patell and Wolfson attempts to capture the anticipated information content of a financial reporting event by examining the behavior of call option prices on dates leading up to and passing through the disclosure date. As they observe, a time series analysis of option prices can reveal the anticipated increased security price variability even if, ex post, the announced signal has little or no effect on stock price (p. 118).

Operationalizing the Variables

In the original Black-Scholes [1973] model, equilibrium option prices are a function of five variables: stock price, exercise price of the option, time to expiration of the option (i.e., maturity date), the risk free rate of interest, and the standard deviation of the stock's rate of return. Of these variables, the first three can be easily observed; the fourth can be closely approximated; only the fifth variable (σ_i) can not be directly obtained.

A unique feature of the Black-Scholes option pricing model[29] is that it can be used in two ways:

(1) An estimate of the standard deviation generated from historic stock returns can be used in the model with the other three variables to obtain a specification of what the particular option should be priced at; or

(2) The current stock and option prices (from the market) can be simultaneously employed in the model with the other two variables and (by numerical approximation) an implied standard deviation can be calculated.

Black and Scholes [1972] have demonstrated that this model can be used to determine whether call options are "properly priced" when an estimate of the standard deviation, based on an ex post series of stock returns, is utilized. They also showed that the actual standard deviation which would result over the life of an option would be a better input if it were known in advance. Accordingly, they suggest that the model's usefulness depends upon investors' abilities to make good forecasts of the actual standard deviation.

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29 Although the LRA model impounds expectations into its equilibrium option price, it too can be solved two ways.

More recently, Chiras and Manaster [1978] found that (weighted average) implied standard deviations (WISD's) were generally a better predictor of future standard deviations of stock return than actual standard deviations (i.e., those based on past stock price data). They defined (p. 214) implied standard deviation (ISD) as the value of a stock's standard deviation of returns which will equate an observed option price with the price calculated from the option formula. Chiras and Manaster observe:

> ... (E)stimated variances (or their square roots, i.e., ISD's) calculated from option prices should reflect not only the informational content of stock price history but also any other available information. Thus one may suspect that the WISD values reflect future standard deviations more accurately than do the historic sample standard deviations. (p. 218)

The models developed in Chapter 2 are subjected to an iterative numerical analysis procedure to generate ISD's which are the focal point of analysis. The investigation focuses primarily on the output of that equilibrium model to determine if the ISD's do change significantly over time. Blattberg and Gonedes [1974] have presented evidence that suggests the $\dot{\sigma}^2$ is not constant.[30] They observe that even though it appears rates of return on common stock can be characterized as independent drawings from a normal population with presumably constant mean, the variance rates do change.

MacBeth and Merville [1979] conducted an empirical examination of how market prices of call options compared with prices predicted by

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30 Among others, Latané and Rendleman [1976], Schmalensee and Trippi [1978], and MacBeth and Merville [1979] also make this observation.

the model. Their sample included only six firms (common stock) over a one year time period, however, they analyzed in excess of 12,000 option prices. Assuming the model correctly prices at-the-money options with at least 90 days to expiration, they observed that, on average, in-the-money option prices exceeded the model predictions and out-of-the-money option prices were less than predicted. They suggested that this (systematic) mispricing of options may be the result of a nonstationary variance rate in the stochastic process generating stock prices. In an unrelated study, May [1971] found that the variability of stock prices in the week quarterly earnings numbers were publicly released was significantly higher than in surrounding weeks.

To derive a closed form solution to the OPM, B-S assumed that σ^2 of return on the underlying stock was constant through time. While the B-S valuation formula does not strictly hold if the σ^2 rate is stochastic, certain studies have demonstrated that the model performs reasonably well as σ^2 changes (eg. Latané and Rendleman [1976], Schmalensee and Trippi [1978]). More importantly, Merton [1973, p.162-167] shows that the B-S valuation formula is virtually unchanged when the σ^2 rate is changing as a known function of time. In a recent paper Patell and Wolfson [1981] note:

> Merton [1973] has demonstrated that if variance rate is non-constant, but can be expressed as a deterministic function of time, $\sigma^2(t)$, then the variance term in the Black-Scholes formula can be more generally defined as the average variance rate per unit time from the valuation date (t_a) to the option expiration date (t_e):
>
> $$\bar{\sigma}^2(t_a) = (t_e - t_a)^{-1} \int_{t_a}^{t_e} \sigma^2(t)dt$$

> ... Since $\sigma^2(t)$ is a function of the entire time profile of the variance rate between the observation date and the expiration date, it should be sensitive to any changes in the instantaneous variance expected to accompany accounting disclosures during that period. (p. 438-439)

Patell and Wolfson [1979] provide the following interpretation of this integral: by examining the behavior of this average-variance-to-expiration-date statistic surrounding a specifically identifiable point in time (e.g., the disclosure date), the issue of whether or not the market anticipates that release (and hence becomes more volatile) can be addressed. They propose a simple model of the variance profile in which the instantaneous stock return variance rate remains constant except at the date of a potentially informative announcement, at which time it increases. Correspondingly, their average variance to expiration ($\overline{\sigma^2}$ (t)) rises smoothly as the observation date approaches the announcement date (t_0) and declines abruptly immediately following the disclosure (pp. 120-121).

Their characterization of the ISD's time-series behavior suggests the following intuitively appealing "roulette-wheel" story: game participants know that at some predictable, future point in time a roulette wheel will be spun. Players are uncertain as to what the outcome of the spin will be, but not as to when it will occur. On the days leading up to the spin, there is a significant increase in the amount of <u>bets</u> being placed. This increase in betting activity reflects the players' lack of consensus[31] regarding the possible

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31 This lack of consensus can be motivated by a number of factors: diffuse priors, heterogeneous beliefs, different prediction models, different risk preferences, different information sets, etc.

outcome of the game. On the day the wheel is spun and the outcome is made known, the bets clear. Betting precedes the spinning of the roulette wheel because once it's spun and the result is announced, there is no incentive to gamble until the next spin.

Unfortunately this profile of stock return variance proposed by Patell and Wolfson is subject to exogenous contamination. That is, it could be sensitive to "outside" noise. Implicit in their examination of ISD's is the assumption that the average variance usually maintains a "normal" level. To the extent that a stock's return variance impounds information (i.e., stimuli or signals) other than the disclosure event of interest, this contemporaneous volatility must be controlled for.[32] Latané and Rendleman [1976; p. 379] noted that there appears to be "a very strong tendency for the standard deviations which are used to price options to move together over time." They suggest this might be interpreted as a tendency on the part of investors to alter their estimates about the variability of returns from stocks. Perhaps there are identifiable determinants of changes that affect the market's collective assessment of common stock volatility (in some systematic way). This prompted Patell and Wolfson [1980] to construct a market index, consisting of an equally-weighted average of every $\overline{\sigma}^2$ (t) estimate available on each announcement date, to extract the influence of marketwide fluctuations in variance.

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32 For example, OPEC's announcement that oil prices will be raised five dollars a barrel might affect the aggregate market's volatility.

This type of adjustment feature is feasible (and perhaps necessary) for a sample of firms assembled in consistent calendar time. It is obviously inappropriate for a sample of firms matched in event time (i.e., days relative to a dividend announcement). Consequently, the potential for cross-sectional commonalities in changes in the implied variance activity of warrants is not a concern in this study.

Unfortunately, there is another potential source of "noise" that must be controlled. This (firm specific) source of contamination can manifest itself in two forms:

(1) A major difficulty in assessing the information content of only the dividend announcement results because dividend and (quarterly) earnings announcements are oftentimes closely synchronized (see Aharony and Swary [1980]).

(2) Essentially this study examines the second moment of the return distribution during a report period vis-à-vis a non-report period. By assumption, there is an "average" amount of information being released by the firm in the non-report period. To the extent that an above-average amount of information is released[33] by the firm in this non-report period, there is a bias against detecting a significant increase in observed volatility (i.e., the hypothesized variance profile is incorrect) (see Beaver [1968]).

This first source of bias was controlled for by simply excluding firms that issue their dividend and quarterly earnings announcements together. Incorporating this sample selection criterion circumvents the interpretational problems introduced by this joint signal.

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33 For example, if a firm makes public information about a merger, stock split, new management, new product, etc.

This second source of bias was controlled for by establishing a sufficiently wide time horizon (i.e., experimental window) surrounding the disclosure event, differencing the ISD's, and averaging across the differences. In addition, the Wall Street Journal Index was examined through the sampling periods to insure that no other firm-specific disclosure was contemporaneously made that might affect asset pricing.

3.5 Testable Implications

Structuring this information-content-of-dividends experiment around the output of the warrant pricing models produces a number of testable implications.

However, when establishing empirically testable hypotheses, care must be taken to ensure the research methodology is designed to control for any variables that are systematically related to the independent (experimental) variable. Theoretical (Verrecchia [1979]) as well as empirical (Reinganum [1979], Banz [1979], and Sandretto [1979]) evidence exists concerning the relationship between firm size and the mean of the distribution of abnormal (excess) returns. No evidence is currently available concerning the second moment (variance) of the distribution of returns and size; however, Ben-Zion and Shalit [1975] found that smaller firms have significantly higher betas than do larger firms. This study does not involve residual analysis; nor does it require beta stability in the traditional fashion. However, it seems likely that firm size is systematically related to stock price variability. To control for the potential contamination of the independent variable, the size issue is concurrently examined.

Relationship of Firm Size to Stock Variability

The efficient market hypothesis stipulates that security prices "fully reflect" some set of (existing) information and correspondingly that security prices adjust to new information in a rapid (instantaneous) and unbiased manner (Fama [1970]).

The issue, however, is not really whether the capital market is efficient or not, but the extent to which it is. Part of the anomalies literature (see Ball [1978] for a review) suggests differences in efficiency might exist for different classes (or types) of securities.

Verrecchia (1979) provided an analysis that suggests:

> (T)he relative degree of efficiency of a security (i.e., the extent to which a price 'reflects' the true distribution or returns) is predicated on the number of traders who actively participate in a market for the security. (p. 89)

As a measure (or surrogate) of market participation, he suggests a variety of observable market phenomena: trading volume, number of shares outstanding, number of stockholders per firm, or relative size. Of particular interest is the final measure -- firm size (as determined by market value of outstanding shares). If there is more trading in the stock of firms with larger market values and if market prices of these firms anticipate an accounting disclosure to a greater extent than the prices of small firms (or conversely, demonstrate relatively lower implied variability), then there would be several interesting implications to accounting policy makers. Verrecchia suggests that since accounting information may be an important low cost information source to investors in small firms, more comprehensive (or frequent) reporting might improve the market efficiency of these firms while having little impact on the efficiency of larger firms.

Therefore, it is conjectured that, because "smaller" firms involve less market participation, that is, there is relatively less consensus as to what an anticipated accounting release will mean, there should be evidence of higher implied variability near the disclosure date for such firms. In Verrecchia's terms, because fewer traders participate in the market for smaller firms' stocks, it takes more time for the price to converge to its equilibrium value (i.e., for a consensus to obtain).

Reilly [1975] has suggested the market may actually be "tiered;" that is, consist of more than one layer with respect to (absolute) firm size. This could affect tests of market efficiency, or suggest alternative trading strategies, or generate materially different transaction costs.

Sandretto's [1979] results indicated that the possible misspecification (of the two-parameter CAPM) increases as firm size decreases (p. 121). Although his market efficiency tests (based upon both P/E and EPS ratios) generated conflicting results, he concluded that market efficiency appeared to be related to firm size.

This aspect of the study compares different parameter estimates for two mutually exclusive portfolios of firms formed on the basis of one measure of size, total capitalized market value.

The point of this part of the analysis is to empirically examine the hypothesis that the stock price of larger firms is relatively less volatile than the stock price of smaller firms. It is conceivable that the dividend disclosure may be of significance (i.e., possess information content) to investors in "small" firms but also redundant (or irrelevant) as a signal to investors in "large" firms.

Testable Implications Concerning the Time Series Behavior of the ISD's

Efficient markets theory specifies that if security prices do, in fact, "fully reflect" (i.e., adjust rapidly and in an unbiased manner to) new information as it becomes available, then changes in stock prices (mean or variance) should reflect the flow of information to market participants.

To the extent there is an "average" amount of investor uncertainty regarding the performance and opportunities of firms competing in the market place, stock price behavior, specifically the variance, is presumed to be relatively stable. Analogously, to the extent no new information is released (or anticipated to be released) to the market, and presuming stock price behavior reflects that flow of information to market participants, one could hypothesize a relatively constant time-series path of ISD's. However, if the market anticipates the release of a dividend signal at some predictable point in the future, one might also hypothesize an increase in firm-specific variability reflecting a lack of consensus concerning that about-to-be-released announcement in the time period leading up to its disclosure.

That exact process is formally modeled in Chapter 4 and empirical hypotheses are constructed that can be used to test these implications. A testing procedure designed by Schipper and Thompson [1983] is employed which allows the differences in ISD's over time within a firm to be examined. In addition, their methodology provides a convenient portfolio interpretation to the tests that allows these time-series differences to be cross-sectionally aggregated. This feature also facilitates examination of the firm size effect.

Summary

This chapter has provided an overview of the methodological procedures employed herein to examine the information-content-of-dividends hypothesis. It reviewed the sampling procedures and laid out the techniques used to estimate the WPM parameters. It also reviewed the concept of the implied standard deviation (ISD) and specified how this concept could be implemented in empirical tests. Finally it presented some testable implications of the ISD concept and related them to firm size and dividend announcement. The next chapter formally models these implications, delineates certain testable hypotheses, and presents the results of those tests.

CHAPTER 4

EMPIRICAL TESTS

The purpose of this chapter is to specify the empirical procedures that are employed to test the information-content-of-dividends hypothesis. It reviews the formal hypotheses that are constructed, the empirical tests of those hypotheses, and the statistical results of those tests. The chapter is organized as follows: section one provides a model of the information arrival process. Section two lays out the two basic sets of hypotheses that are tested. Section three lays out an additional set of hypotheses to test the firm-size effect. Section four presents some preliminary data analysis and the empirical results of the first set of hypotheses. Section five presents the empirical results of the second hypothesis set tested in conjunction with the firm-size effect.

4.1 Modelling the Information Arrival Process

To characterize the variability of stock returns in event time, let each firm j (j=1,J) have a time series of implied standard deviations (ISD's) generated from the WPM such that:

$$\underline{\Delta ISD}_j = \underline{\Delta SD}_j + \underline{\varepsilon}_j$$

That is, observed differences are equal to the true differences plus any measurement error associated with the calculation of the implied standard deviations.

Define: $\underline{\Delta ISD}_j$ ≡ A (t x 1) time series vector of observed implied standard deviation differences. That is, each element represents the actual difference calculated between any two chronologically consecutive ISD's. For each firm at each announcement date, 30 ISD's were computed. Therefore, there are 29 elements in this t x 1 row vector per firm j, per event.

$\underline{\Delta SD}_j$ ≡ A (t x 1) time series vector of "true" ISD differences.

$\underline{\varepsilon}_j$ ≡ A (t x 1) vector of error terms. These errors of the ΔISD's around the ΔSD's are assumed to be homoscedastic cross-sectionally as well as serially independent and identically distributed [IID] intertemporally (i.e., within each firm across time).

In the absence of information arrival, a relatively constant series of implied standard deviations would be expected. This suggests that the ΔSD_j's (true differences) should be equal to zero. This assumption is consistent with Patell and Wolfson's [1979] characterization of the instantaneous variance profile remaining relatively level during a period of "normal information arrival" (p.120).

Ohlson [1979] demonstrated analytically that the variability of stock price - and return - should be relatively large at the time information is disclosed. In the spirit of this result he concluded that disclosure of information precipitates the need for a revaluation of the asset (pp. 226-227). Under the hypothesis that dividend announcements have no impact on security returns (i.e., the information content of dividends is zero), no change over the complete implied standard deviation profile is expected (i.e., ΔSD_j parameters should be equal to zero).

However, if dividend announcements have an impact on the return generating process, this implies the ΔSD_j's will be nonzero at certain critical times surrounding the event date. The empirical results of Patell and Wolfson [1979], May [1971], and Beaver [1968], and the analytical results of Ohlson [1979] suggest that that behavior of common stock return variances in the time periods prior to, during, and immediately after[34] an information release should be characterized as increasing, decreasing, and constant, respectively. That is, the time-series profile of these ISD differences should portray the flow of information to the market. Immediately before the disclosure of the dividend, a large variance in stock price would reflect the market participants' uncertainty which they anticipate will be resolved when the announcement is made. At announcement, this uncertainty should subside, driving down the stock's variance. Finally, some time after the announcement's effect has been assimilated into price, an average or typical amount of price variability should exist. This specification suggests that the time-series behavior of the ISD differences (i.e., ΔSD_j's) should be positive, negative, and zero for these respective regimes.

In this study the set of 29 sequential differences is decomposed into the following regimes: ΔSD_1 through ΔSD_{22} are classified as ex-ante (prior to announcement) observations; ΔSD_{23} and ΔSD_{24} are classified as the during announcement period[35] and ΔSD_{25} through ΔSD_{29}

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[34] Before the anticipation of the arrival of other information.

[35] To account for the possible one day time lag that could occur between announcement of the dividend and publication of the announcement (in the financial news media), a two-day event period was decided upon.

are classified as ex-post observations. These regimes are labeled XA, A, and XP, respectively. For each firm, the actual calculation of the ISD's is consistent in event-time. A total of 30 ISD's are generated from the WPM for each event. This process is carried out 24 days prior to, actually on the announcement date, and 5 days following it. ISD_{-24} is the implied standard deviation computed 24 days prior to the dividend announcement; ISD_0 is computed the day of the announcement; and ISD_{+5} is computed 5 days after announcement. The difference between ISD_{-24} and ISD_{-23} is labeled ΔISD_1; the difference between ISD_{-23} and ISD_{-22} is labeled ΔISD_2, etc. such that the difference between ISD_{+4} and ISD_{+5} is labeled ΔISD_{29}. The size of this arbitrary window (i.e., time interval) is motivated by Patell and Wolfson's [1979] results and data manageability.

4.2 Formulating the Hypotheses

Two basic sets of hypotheses are tested concerning the impact of the dividend announcement on the sample of firms with actively traded warrants. The first set tests to see whether ΔSD parameters are significantly different from zero. The second set tests to see whether the ΔSD parameters are significantly different from one another. These two sets of hypotheses were tested under two independent assumptions concerning the ΔISD_j's. Individual observations are pooled into cross-sectional portfolios as well as time-series regimes. Different hypotheses regarding the ΔSD parameters are then conducted. In each case, the ε_{jt} terms are assumed to be normally distributed.

No Hypothesized Difference from Zero

The first set of hypotheses tests to see whether the ΔSD parameters are significantly different from zero. These tests are conducted under three different assumptions concerning the cross-sectional ΔSD's [see summary table below].

HYPOTHESIS TEST	PROCEDURE	ASSUMPTIONS CONCERNING THE DISTRIBUTION OF THE: CROSS-SECTIONAL ΔSD's	TIME-SERIES ΔSD's
(1)	PORTFOLIO	The ΔSD's could be DEPENDENT and HETEROSCEDASTIC	IID
(2)	GRAND	INDEPENDENT and IDENTICALLY DISTRIBUTED (IID) (i.e, HOMOSCEDASTIC)	IID
(3)	GLS	INDEPENDENT but the ΔSD's could be HETEROSCEDASTIC	IID

Previously, studies based on OPM output have focused their statistical analysis at the individual firm level. However, in keeping with the spirit of an event study, this methodological design, staged in event time, allows the ΔSD's to be aggregated.

Portfolio Procedure

A test of significance on the average ΔSD_j is performed by aggregating the firm ΔISD_j into an equally weighted portfolio. This procedure allows for dependence and heterscedasticity in the distribution of the cross-sectional ΔSD's. However, within the firm, it assumes the time-series ΔSD's are independent and identically distributed (homoscedastic). The standard error of the averages is estimated by calculating the standard error of the $\Delta ISD_{\bullet t}$ from an equally-weighted portfolio comprised of j=1,J ISD differences consistently matched in event time. This procedure controls for event-time cross-sectional dependence in the ε_{jt}'s as well as differences in their variances.[36] To test for significance a time-series test of the cross-sectional averages is conducted on the following set of hypotheses:

$$H_0^1: \ \overline{\Delta SD}_{\bullet t}^{XA} = 0$$

$$H_0^1: \ \overline{\Delta SD}_{\bullet t}^{A} = 0$$

$$H_0^1: \ \overline{\Delta SD}_{\bullet t}^{XP} = 0$$

HYPOTHESIS TEST (1)

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36 This concept of variance is the statistical notion of variance of the variable of interest. The variable of interest coincidentally happens to be differenced variances (actually standard deviations). Thus the concept of variance is used in two connotations.

Significance Tests Under the Assumption of Independent Cross-Sectional Observations

Under the assumption that the ΔSD_j's are independent across firms, measures of significance of the averages are calculated two ways.

The Grand Procedure

First, the standard error of the averages is calculated by pooling the entire j x t observations (per regime) and treating them as if each is an independent drawing from the same distribution. The standard error calculated in this manner is asymtotically efficient under the assumption that the observations are indeed homoscedastic and independent cross-sectionally (i.e., uncorrelated across firms) as well as independent and identically distributed over time. Significance is tested by calculating grand averages for each regime (consisting of j x t pooled elements) and subjecting them to the following hypotheses:

$$H_0^2:\ \overline{\Delta SD}_{jt}^{XA} = 0 \qquad \text{for } j=1,\ J \text{ and } t=1,\ 22$$

$$H_0^2:\ \overline{\Delta SD}_{jt}^{A} = 0 \qquad \text{for } j=1,\ J \text{ and } t=23,\ 24$$

$$H_0^2:\ \overline{\Delta SD}_{jt}^{XP} = 0 \qquad \text{for } j=1,\ J \text{ and } t=25,\ 29.$$

HYPOTHESIS TEST (2)

The GLS Procedure

Second, still under the assumption of independent ΔSD_j parameters across the sample of firms, the hypothesis that the true underlying standard deviation change is zero can be tested using a generalized least squares (GLS) procedure which efficiently incorporates differences in the precision of each firm's parameter estimate.

This GLS procedure generates an asymtotically efficient test statistic under the assumption that the process generating the observed ΔISD's is independent cross-sectionally but is subject to a different variance for each firm.[37] That is, the process is characterized by a homogeneous variance within individual firms across time, but heterogeneous variances across firms. Consistent with the intuition of Schipper and Thompson [1983], the GLS test statistic[38] measures the significance of the parameter estimate from a portfolio of the J firms where the portfolio weights are proportional to the inverse of the variance estimates from the individual firms. Tests are performed on each time-series regime. The three null hypotheses are:

$$H_0^3\text{:}\quad \Delta\overline{SD}_{jt}^{XA} = 0$$

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37 Homoscedasticity is lost when the error term's variance changes either across time or across categories (sections). GLS is a procedure which encompares all cases that violate the assumptions that the error term is normally distributed and homoscedastic (i.e., $\varepsilon_{jt} \sim N(0,\sigma^2 I)$. For the case when the covariance matrix is not an identitiy matrix (or scalar multiple of it), OLS estimators are not "BLUE," they are unbiased and linear, but not minimum variance (see Lee and Vinso [1980]).

38 See Appendix F for a discussion of this statistic.

$$H_0^3: \ \overline{\Delta SD}_{jt}^{A} = 0$$

HYPOTHESIS TEST (3)

$$H_0^3: \ \overline{\Delta SD}_{jt}^{XP} = 0$$

Results of these three hypothesis tests are reported in Section 4.4.

No Hypothesized Difference from Each Other

The second hypothesis set tests to see whether the ΔSD parameters are significantly different from one another. The set of pooled parameters [as specified in hypothesis test (2)] is subjected to the following hypothesis test:

HYPOTHESIS TEST (4)

$$H_0^4: \ \overline{\Delta SD}_{jt}^{XA} = \overline{\Delta SD}_{jt}^{A} = \overline{\Delta SD}_{jt}^{XP} \qquad \text{for } j=1,\ J \text{ and } t=1,\ 29$$

The null hypothesis tested is that the differences between the means of three populations (i.e., $\mu_1 - \mu_2$, $\mu_1 - \mu_3$ and $\mu_2 - \mu_3$) are all equal to zero against the alternative hypothesis that one or more are different from zero. It is assumed that observations are drawn from normally distributed populations.

Furthermore, it is assumed that the samples are random draws from their respective populations and independent from one another. The major consequence of this last assumption (see Glass and Stanley [1970; p. 295]) is that any two sample means should be perfectly uncorrelated across infinitely many pairs of samples.

Finally, it is further assumed that the variances of the respective populations are equal. This assumption is necessary for hypothesis testing based on the F distribution (Kirk [1968, p. 43]) used to conduct an ANOVA. Unfortunately, it is not consistent with the distributional assumptions concerning the cross-sectional ΔSD's (see p. 78) allowed under the PORTFOLIO and GLS procedures. Therefore, the ANOVA procedure is carried out under the assumptions specified for the GRAND procedure [hypothesis test (2)] and according to the pooling technique described therein.

The results of this hypothesis test are reported in Section 4.6.

4.3 Testing the Firm-Size Hypothesis

To investigate whether the dividend announcement has a differential impact on the ΔSD_j parameters of small firms vis-à-vis large firms, an analogous set of tests is conducted.

Firms are ranked on the basis of market value. Market value is estimated by multiplying the number of common shares outstanding immediately prior to the dividend announcement times a 200 day moving average stock price available at that time. The sample is then subdivided into two groups comprised of an equal number of firms. The groups are labeled the large-firm group and small-firm group, respectively. Hypotheses 1 through 3 are then tested independently on each of the two groups. These tests are labeled hypothesis test (1'), (2'), and (3'), respectively. The results of this analysis are reported in Section 4.5.

In addition, to test whether the ΔSD-small parameters are significantly different from the ΔSD-large, the set of pooled parameters specified in hypothesis test (4) is subjected to the following general null hypothesis:

$$H_O^5: \ \Delta SD \bullet SMALL = \Delta SD \bullet LARGE$$ HYPOTHESIS TEST (5)

The alternative hypothesis is that the small and large parameters are not equal in one or more regimes. A two-way ANOVA is conducted which facilitates a comparison of each time regime by firm size, allowing hypothesis test (4) to be examined in conjunction with hypothesis test (5). The results of this part of the analysis are reported in Section 4.6.

4.4 Data Analysis and Empirical Results

This section presents the results of the first three hypothesis tests (1), (2) and (3), along with some preliminary data analysis.

Preliminary Data Analysis: Individual Firm Results

To provide more insight into the aggregation process, some descriptive results are presented at the individual firm-level. To examine the time-series behavior of the ISD differences, each individual firm's set of 29 ISD's is also decomposed into three independent regimes as previously described. For each individual firm (j=1,J), the following three hypotheses are tested:

$$H_O: \ \Delta\overline{SD}_{jt}^{XA} = 0 \qquad t=1,22$$

$$H_O: \ \Delta\overline{SD}_{jt}^{A} = 0 \qquad t=23,24$$

$H_0\colon \; \Delta\overline{SD}_{jt}^{XP} = 0 \qquad t=25,29$

Tables One and Two present the individual firm results for announcement date (A-date) one for WPM's #1 and #2 respectively. A-date one is the dividend announcement closest to, but before the expiration of the warrant. Because of the sensitivity of the option pricing model to the time-to-maturity parameter (T), any warrants within one month of expiration are excluded.[39] There were three such warrants.

Tables Three and Four present the individual firm results for the respective models for A-date two. Announcement date two is the second closest dividend announcement to expiration. In both cases all firms are consistently matched in event-time, not calendar-time.

For WPM #1 at the first dividend announcement date (Table One), the ex-ante regime contains 30/40 (75%) positive t-values, of which four are significantly[40] different from zero. The announcement regime contains 19/40 (47.5%) negative t-values, of which only one is significantly different from zero. The ex-post regime contains 14/40 (35%) negative t-values. Five are significantly different from zero, four positive, one negative. It is interesting to observe that in the announcement date t-statistic column, there are four positive t-values which are significantly different from zero. This is not consistent

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39 Manaster and Rendleman [1982; p.1046] used a similar criterion.

40 At α=.05 level of significance for a two-tailed test with 21 degrees of freedom.

TABLE ONE
INDIVIDUAL FIRM RESULTS FOR WPM #1 AT A-DATE ONE

FIRM NO.	EX-ANTE MEAN	STANDARD DEVIATION*	T-STATISTIC**	ANNOUNCEMENT MEAN	T-STATISTIC**	EX-POST MEAN	T-STATISTIC**
1	0.00252	0.02075	0.55715	0.01602	1.06674	0.00449	0.47273
2	0.01432	0.04812	1.36362	0.01095	0.31441	0.00186	0.08444
3	-0.00326	0.02473	-0.60348	-0.01195	-0.66766	-0.00780	-0.68906
4	0.00783	0.04825	0.74373	-0.02318	-0.66379	0.05065	2.29333**
5	0.01435	0.02546	2.58360**	-0.00310	-0.16824	0.02914	2.50043**
6	-0.00057	0.25621	-0.01021	-0.15355	-0.82807	0.07991	0.68138
7	0.00774	0.06522	0.54383	-0.01602	-0.33939	0.02336	0.78248
8	0.00388	0.02424	0.73411	-0.03495	-1.99218	0.00882	0.79491
10	0.00130	0.05959	0.10026	0.13576	3.14783**	-0.02408	-0.88281
11	0.00401	0.03368	0.54533	0.01380	0.56614	-0.01610	-1.04433
12	-0.01150	0.05133	-1.02667	0.03567	0.96016	0.03905	1.66201
13	0.01372	0.05056	1.24333	0.04136	1.13028	0.01840	0.79505
14	0.01762	0.02691	3.00107**	0.04839	2.48459**	-0.04003	-3.24979**
15	0.01895	0.06787	1.27937	0.01048	0.21335	0.06218	2.00150
17	0.00766	0.05453	0.64391	0.02976	0.75407	0.01438	0.57611
18	0.00711	0.05595	0.58246	-0.03509	-0.86656	-0.01207	-0.47129
19	0.01712	0.05956	1.31740	0.02592	0.60130	0.01442	0.52893
20	0.00490	0.03978	0.56424	0.00368	0.12782	0.00411	0.22572
21	0.03212	0.38207	0.38520	-0.19721	-0.71318	0.13524	0.77330
22	0.00363	0.02707	0.61447	0.02866	1.46286	0.01342	1.08305
23	0.04951	0.11538	1.96651	-0.10570	-1.26578	0.04729	0.89541
24	0.04161	0.17898	1.06526	-0.07364	-0.56849	-0.01077	-0.13146
25	-0.00714	0.10151	-0.32245	0.33536	4.56474**	-0.02641	-0.56839
26	0.00865	0.02855	1.38800	0.04132	1.99971	0.02056	1.57326
27	0.00029	0.03218	0.04188	0.06007	2.57920**	-0.00122	-0.08282
28	0.01795	0.06820	1.20636	0.04776	0.96760	0.07932	2.54087**
29	-0.00399	0.04339	-0.42164	-0.00814	-0.25921	0.03262	1.64240
30	-0.00279	0.08411	-0.15213	0.05796	0.95213	-0.01001	-0.26000
31	0.01642	0.13196	0.57010	-0.05467	-0.57243	-0.01197	-0.19817
32	0.01538	0.05390	1.30789	0.00258	0.06614	0.04943	2.00348
33	-0.02057	0.08742	-1.07842	-0.18495	-2.92319**	-0.01854	-0.46332
34	-0.00083	0.02827	-0.13439	-0.01422	-0.69500	-0.00883	-0.68237
36	0.00469	0.11681	0.18416	0.07585	0.89720	0.05374	1.00508
37	-0.00694	0.06102	-0.52149	-0.05324	-1.20553	-0.00727	-0.26028
38	-0.00335	0.03388	-0.45331	-0.05001	-2.03952	0.00193	0.12445
39	0.02613	0.05622	2.12982**	-0.03105	-0.76311	0.04854	1.88622
40	0.00254	0.03756	0.30993	0.00316	0.11625	-0.00158	-0.09190
41	0.00730	0.06229	0.53741	-0.05030	-1.11574	0.04331	1.51899
42	0.03105	0.06516	2.18366**	0.01202	0.25488	0.02986	1.00113
43	0.02447	0.07806	1.43637	-0.07975	-1.41161	0.07840	2.19418**

* The firm-specific standard deviation is estimated for each of the regimes using the 22 (ex-ante) observations prior to the announcement.

** The .05 level of significance for a one-tailed test with 21 degrees of freedom is 1.721. The .05 level for a two-tailed test is 2.080. Significant t-values (for a two-tailed test) are also double-starred.

TABLE TWO
INDIVIDUAL FIRM RESULTS FOR WPM #2 AT A-DATE ONE

FIRM NO.	EX-ANTE MEAN	STANDARD DEVIATION*	T-STATISTIC**	ANNOUNCEMENT MEAN	T-STATISTIC**	EX-POST MEAN	T-STATISTIC**
1	0.00251	0.02073	0.55500	0.01601	1.06710	0.00448	0.47213
2	0.01441	0.04812	1.37239	0.01102	0.31642	0.00193	0.08762
3	-0.00306	0.02475	-0.56658	-0.01181	-0.65931	-0.00784	-0.69203
4	0.00809	0.04833	0.76707	-0.02296	-0.65640	0.05088	2.29993**
5	0.01436	0.02540	2.59058**	-0.00310	-0.16863	0.02913	2.50548**
6	-0.00077	0.25589	-0.01384	-0.15337	-0.82813	0.07982	0.68146
7	0.00787	0.06516	0.55378	-0.01592	-0.33758	0.02349	0.78756
8	0.00416	0.02469	0.77246	-0.03576	-2.00120**	0.00925	0.81847
10	0.00150	0.05944	0.11568	0.13459	3.12858**	-0.02413	-0.88687
11	0.00395	0.03302	0.54868	0.01362	0.56992	-0.01592	-1.05329
12	-0.01135	0.05135	-1.01308	0.03582	0.96383	0.03918	1.66689
13	0.01372	0.05056	1.24333	0.04136	1.13028	0.01840	0.79505
14	0.01780	0.02691	3.03191**	0.04856	2.49332**	-0.03989	-3.23843**
17	0.00745	0.05385	0.63419	0.02895	0.74281	0.01415	0.57406
18	0.00732	0.05600	0.59858	-0.03520	-0.86850	-0.01183	-0.46151
19	0.01712	0.05956	1.31736	0.02592	0.60130	0.01442	0.52893
20	-0.00861	0.08317	-0.47425	0.00368	0.06114	0.00411	0.10796
21	0.03208	0.38204	0.38481	-0.19723	-0.71331	0.13520	0.77313
22	0.00407	0.02791	0.66741	0.02921	1.44606	0.01390	1.08802
23	0.04946	0.11531	1.96550	-0.10562	-1.26559	0.04730	0.89614
24	0.04146	0.17870	1.06310	-0.07363	-0.56930	-0.01080	-0.13202
25	-0.00708	0.10078	-0.32178	0.33335	4.57025**	-0.02654	-0.57532
26	0.00881	0.02857	1.41335	0.04146	2.00508	0.02070	1.58286
27	0.00029	0.03218	0.04182	0.06007	2.57920**	-0.00122	-0.08282
28	0.01795	0.06820	1.20636	0.04776	0.96760	0.07932	2.54087**
29	-0.00388	0.04322	-0.41146	-0.00792	-0.25319	0.03262	1.64886
30	-0.00243	0.08220	-0.13557	0.05449	0.91592	-0.01044	-0.27747
31	0.01483	0.14333	0.47402	-0.05112	-0.49280	-0.01054	-0.16065
32	0.01520	0.05347	1.30289	0.00313	0.08088	0.04926	2.01265
34	-0.00090	0.02723	-0.15185	-0.01438	-0.72967	-0.00832	-0.66751
36	0.00448	0.11591	0.17695	0.07517	0.89606	0.05334	1.00535
37	-0.00692	0.06111	-0.51910	-0.05310	-1.20059	-0.00719	-0.25704
38	-0.00302	0.03410	-0.40643	-0.04993	-2.02312	0.00227	0.14543
39	0.02633	0.05622	2.14646**	-0.03090	-0.75942	0.04871	1.89283
40	0.00249	0.03676	0.31065	0.00307	0.11539	-0.00175	-0.10400
41	0.00749	0.06237	0.55015	-0.05018	-1.11165	0.04350	1.52369

* The firm-specific standard deviation is estimated for each of the regimes using the 22 (ex-ante) observations prior to the announcement.

** The .05 level of significance for a one-tailed test with 21 degrees of freedom is 1.721. The .05 level for a two-tailed test is 2.080. Significant t-values (for a two-tailed test) are also double-starred.

TABLE THREE
INDIVIDUAL FIRM RESULTS FOR WPM #1 AT A-DATE TWO

FIRM NO.	EX-ANTE MEAN	STANDARD DEVIATION*	T-STATISTIC**	ANNOUNCEMENT MEAN	T-STATISTIC**	EX-POST MEAN	T-STATISTIC**
1	0.00150	0.01574	0.43723	-0.00124	-0.10885	-0.00406	-0.56351
2	0.00220	0.04426	0.22809	0.04105	1.28149	0.00051	0.02517
3	-0.00130	0.01383	-0.43190	0.00632	0.63141	-0.00252	-0.39807
4	0.00062	0.03663	0.07813	-0.02800	-1.05617	0.00453	0.27017
5	-0.00015	0.01307	-0.05260	0.00385	0.40700	0.00340	0.56831
6	-0.00204	0.04942	-0.18963	0.05270	1.47340	-0.01103	-0.48759
7	-0.00007	0.03688	-0.00892	-0.05300	-1.98563	-0.00228	-0.13506
8	0.00076	0.02691	0.12925	-0.00303	-0.15558	0.00559	0.45382
9	0.00142	0.02251	0.28879	0.00658	0.40389	0.00080	0.07764
10	0.00603	0.03068	0.90020	-0.03381	-1.52266	-0.00794	-0.56539
11	0.00146	0.02412	0.27747	0.00047	0.02692	-0.00572	-0.51809
12	-0.00243	0.03130	-0.35641	-0.00957	-0.42246	0.01951	1.36175
13	0.00345	0.01912	0.82690	0.02096	1.51467	0.02418	2.76282**
14	0.00743	0.02984	1.14134	-0.00349	-0.16160	0.00349	0.25551
15	0.01309	0.03045	1.97004	0.07425	3.36917**	0.00626	0.44913
16	-0.00881	0.74625	-0.05412	-0.07059	-0.13070	0.03217	0.09418
17	-0.00197	0.02714	-0.33278	-0.00485	-0.24691	0.01711	1.37729
18	0.00280	0.03835	0.33517	-0.04358	-1.57013	-0.01000	-0.56966
19	0.03098	0.24055	0.59018	0.00996	0.05721	0.05700	0.51767
20	0.00656	0.01564	1.92224	0.00127	0.11220	0.00132	0.18438
21	0.02460	0.10174	1.10796	0.04042	0.54893	-0.02754	-0.59137
22	-0.00403	0.03929	-0.46992	-0.00252	-0.08862	0.01157	0.64333
23	0.00376	0.08444	0.20422	0.02898	0.47420	0.00713	0.18447
24	0.00635	0.15062	0.19314	-0.02634	-0.24163	0.01266	0.18363
25	0.00079	0.04854	0.07479	-0.01961	-0.55820	0.01187	0.53424
26	-0.00001	0.02815	-0.00126	-0.02098	-1.02977	-0.00141	-0.10943
27	-0.00626	0.02123	-1.35101	-0.06809	-4.43146**	0.00507	0.52173
28	0.00145	0.01630	0.40709	-0.00999	-0.84682	0.01140	1.52792
29	-0.00171	0.02842	-0.27544	0.01079	0.52458	0.00622	0.47813
32	0.01083	0.07443	0.66654	-0.08714	-1.61765	0.02877	0.84445
33	-0.00062	0.14344	-0.01985	-0.01780	-0.17146	0.00494	0.07524
34	0.00059	0.01918	0.14118	-0.02384	-1.71740	-0.01354	-1.54225
35	-0.00795	0.05588	-0.65167	-0.02198	-0.54348	-0.00170	-0.06646
36	-0.00032	0.08470	-0.01714	0.01271	0.20734	-0.00138	-0.03559
37	0.00758	0.05055	0.68754	-0.03052	-0.83421	0.00760	0.32846
39	0.00518	0.01771	1.33988	-0.01069	-0.83401	0.02003	2.47085**
40	0.00020	0.03607	0.02564	-0.03805	-1.45755	0.01623	0.98301
41	0.01997	0.05971	1.53278	0.01071	0.2478	0.00544	0.19904
42	-0.00159	0.02071	-0.35209	0.00184	0.12276	0.00722	0.76162
43	0.00178	0.06599	0.12393	-0.00818	-0.17127	0.01684	0.55750

* The firm-specific standard deviation is estimated for each of the regimes using the 22 (ex-ante) observations prior to the announcement.

** The .05 level of significance for a one-tailed test with 21 degrees of freedom is 1.721. The .05 level for a two-tailed test is 2.080. Significant t-values (for a two-tailed test) are also double-starred.

TABLE FOUR
INDIVIDUAL FIRM RESULTS FOR WPM #2 AT A-DATE TWO

FIRM NO.	EX-ANTE MEAN	STANDARD DEVIATION*	T-STATISTIC**	ANNOUNCEMENT MEAN	T-STATISTIC**	EX-POST MEAN	T-STATISTIC**
1	0.00135	0.01524	0.40691	-0.00133	-0.12058	-0.00349	-0.50029
2	0.00243	0.04432	0.25137	0.04100	1.27820	0.00071	0.03500
3	-0.00099	0.01365	-0.33182	0.00725	0.73387	-0.00198	-0.31690
4	0.00121	0.03765	0.14777	-0.02837	-1.04114	0.00500	0.29013
5	-0.00014	0.01255	-0.04947	0.00383	0.42167	0.00318	0.55356
6	-0.00200	0.04804	-0.19092	0.05129	1.47517	-0.01102	-0.50114
7	0.00056	0.03817	0.06669	-0.05279	-1.91092	-0.00199	-0.11390
8	0.00119	0.03050	0.17839	-0.00254	-0.11507	0.00590	0.42261
9	0.00166	0.02250	0.33765	0.00681	0.41819	0.00101	0.09807
10	0.00541	0.03046	0.81411	-0.03294	-1.49419	-0.00813	-0.58310
11	0.00166	0.02513	0.30297	0.00056	0.03079	-0.00533	-0.46336
12	-0.00200	0.03147	-0.29168	-0.00920	-0.40393	0.01995	1.38494
13	0.00345	0.01912	0.82690	0.02096	1.51467	0.02418	2.76282**
14	0.00771	0.03015	1.17153	-0.00322	-0.14756	0.00375	0.27172
16	-0.00845	0.71609	-0.05408	-0.06937	-0.13385	0.03165	0.09656
17	-0.00127	0.02724	-0.21374	-0.00284	-0.14405	0.01628	1.30566
18	0.00299	0.03953	0.34626	-0.04444	-1.55332	-0.00962	-0.53166
19	0.03098	0.24055	0.59019	0.00996	0.05721	0.05700	0.51767
20	0.00656	0.01564	1.92224	0.00127	0.11220	0.00132	0.18438
21	0.02455	0.10180	1.10507	0.04039	0.54820	-0.02750	-0.59016
22	-0.00416	0.04464	-0.42697	-0.00230	-0.07119	0.01184	0.57944
23	0.00363	0.08404	0.19818	0.02881	0.47366	0.00697	0.18119
24	0.00594	0.14825	0.18365	-0.02523	-0.23515	0.01203	0.17728
25	0.00116	0.04662	0.11448	-0.01675	-0.49643	0.00988	0.46299
26	0.00035	0.02828	0.05604	-0.02072	-1.01233	-0.00110	-0.08498
27	-0.00626	0.02123	-1.35101	-0.06809	-4.43146**	0.00507	0.52173
28	0.00145	0.01630	0.40709	-0.00999	-0.84682	0.01140	1.52792
29	-0.00159	0.02891	-0.25205	0.01094	0.52286	0.00641	0.48439
32	0.01101	0.07413	0.68064	-0.08726	-1.62643	0.02857	0.84198
34	0.00077	0.01697	0.20716	-0.02250	-1.83195	-0.00939	-1.20884
35	-0.00790	0.05578	-0.64931	-0.02191	-0.54272	-0.00176	-0.06893
36	-0.00014	0.08335	-0.00757	0.01290	0.21384	-0.00185	-0.04849
37	0.00766	0.05062	0.69363	-0.03016	-0.82323	0.00730	0.31505
39	0.00559	0.01775	1.44340	-0.01029	-0.80100	0.02043	2.51451**
40	0.00039	0.03478	0.05085	-0.03514	-1.39600	0.01499	0.94158
41	0.02053	0.06014	1.56410	0.01104	0.25364	0.00583	0.21178

* The firm-specific standard deviation is estimated for each of the regimes using the 22 (ex-ante) observations prior to the announcement.

** The .05 level of significance for a one-tailed test with 21 degrees of freedom is 1.721. The .05 level for a two-tailed test is 2.080. Significant t-values (for a two-tailed test) are also double-starred.

with the characterization of the information arrival process modeled in this study. However, in each instance, the ex-post mean is negative, once, significantly so. It appears that for these four firms either the information did not reach the market immediately or the market was unable to resolve the uncertainty associated with the announcement (i.e., impound the information contained in the disclosure) instantaneously. Very similar results are obtained using WPM #2 (Table Two).[41] For the XA, A, and XP regimes, respectively, there are 3, 5, and 4 t-values significantly different from zero. Again the apparently anomalous result occurs at the announcement date.

For WPM #1 at the second dividend announcement date (Table Three), the ex-ante regime contains 25/40 (62.5%) positive t-values, none of which are significantly different from zero. The announcement regime contains 24/40 (60%) negative t-values, two of which are significantly different from zero, one positive, one negative. The ex-post regime contains 12/40 (30%) negative t-values; two are significantly different from zero, both positive. Again, very similar results are obtained using WPM #2 (Table Four).[41] The XA, A, and XP regimes show 0, 1, and 2 significant t-values, respectively. The methodology appears to be less powerful farther back (in time) from the warrant's expiration.

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[41] Recall, there are 4 fewer firms in any of the empirical tests involving WPM #2 [see footnote 27].

Results of Hypothesis Tests (1), (2), and (3)

This set of hypotheses tested to see whether the ΔSD parameters were significantly different from zero at the portfolio level.

To test hypothesis (1), individual firm differences were pooled into equally-weighted portfolios, consistently matched in event time, from which cross-sectional averages (labeled ABARS) were constructed. Plot One graphs the time-series behavior of these averages. For both WPM's #1 and #2, at A-date one, the time-series profile of these pooled ΔISD_J's is striking. In three out of the four cases, there appears to be a reduction of uncertainty at announcement. It is noticeably positive on average during the ex-ante regime, drops sharply at announcement and then resumes its upward climb.

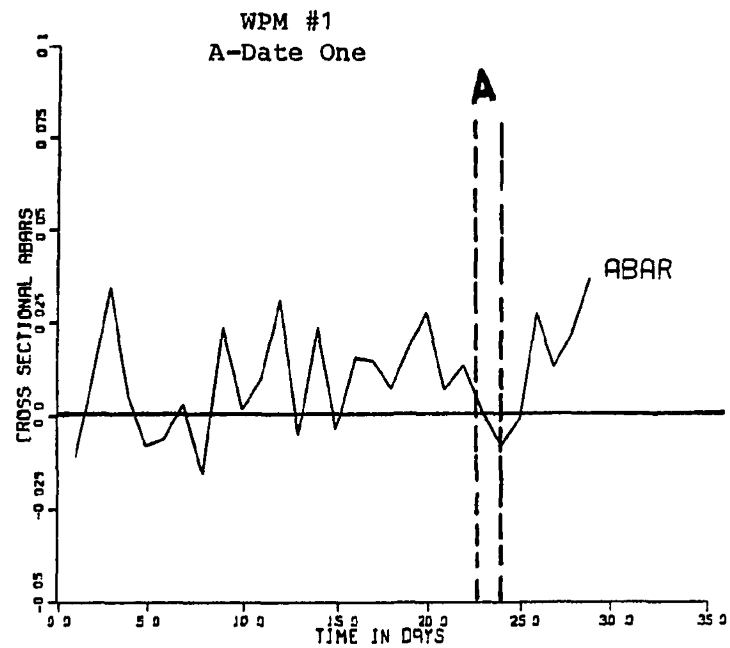
These graphical results are borne out in Table Five. Table Five reports the "ABARS" (i.e., the cross-sectional averages) for each WPM at each A-date. The summary table below indicates the percentage of ABARS for each regime (for each WPM and A-date) that are positive:

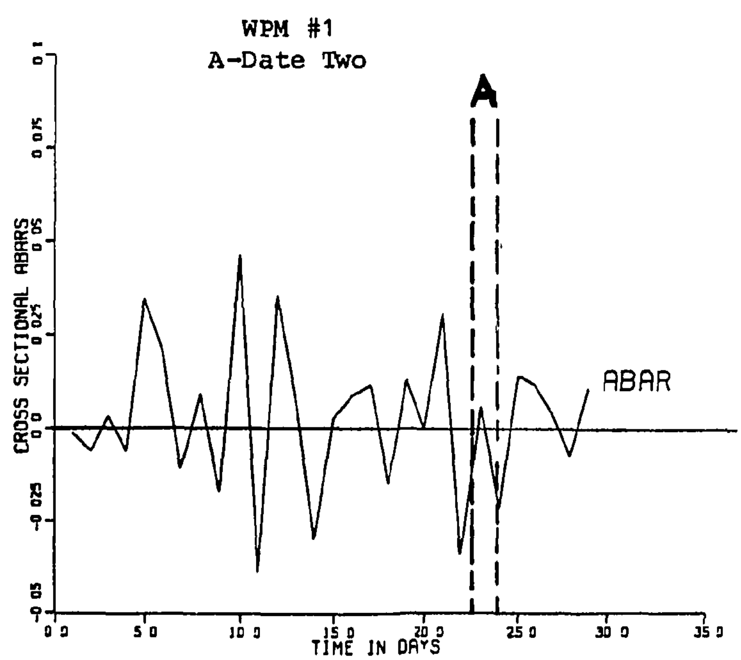
PERCENTAGE OF POSITIVE ABARS

REGIME	WPM #1 A-Date One	WPM #2 A-Date One	WPM #1 A-Date Two	WPM #2 A-Date Two
XA	$\frac{16}{22}$ = 73%	$\frac{17}{22}$ = 77%	$\frac{12}{22}$ = 55%	$\frac{15}{22}$ = 68%
A	$\frac{1}{2}$ = 50%	$\frac{2}{2}$ = 100%	$\frac{1}{2}$ = 50%	$\frac{1}{2}$ = 50%
XP	$\frac{4}{5}$ = 80%	$\frac{4}{5}$ = 80%	$\frac{4}{5}$ = 80%	$\frac{4}{5}$ = 80%

PLOT ONE

Time-Series Profile of Cross-Sectionally Averaged ISD Differences (ABARS) Plotted in Event Time



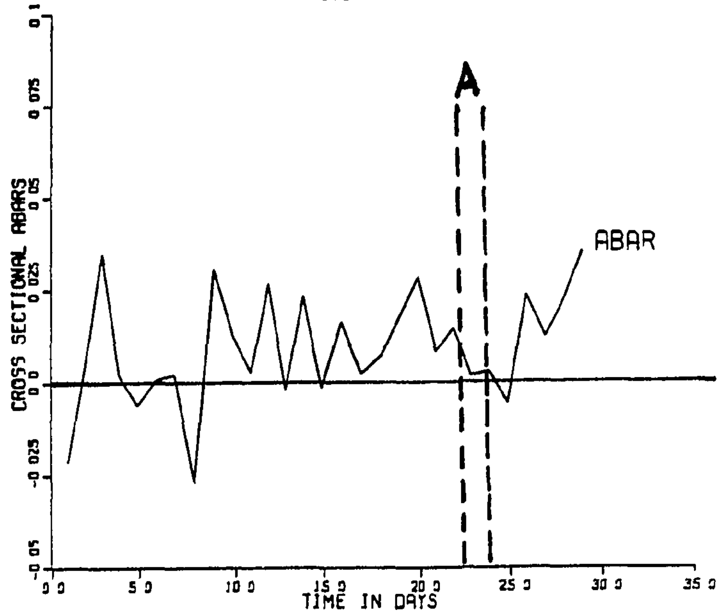


Dividend Announcement Date is Day 24-25 (dashed line).

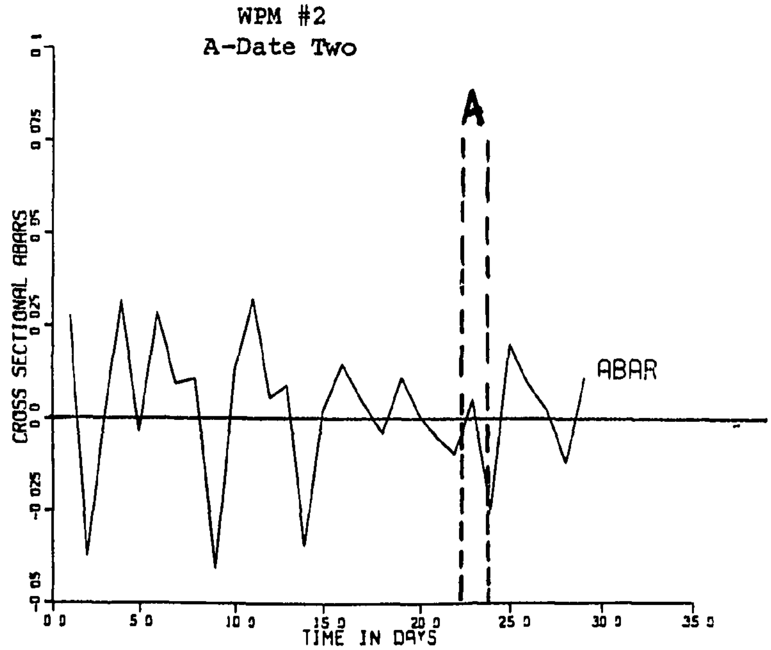
PLOT ONE

Time-Series Profile of Cross-Sectionally Averaged ISD Differences (ABARS) Plotted in Event Time

WPM #2
A-Date One



WPM #2
A-Date Two



Dividend Announcement Date is Day 24-25 (dashed line).

TABLE FIVE
CROSS-SECTIONAL AVERAGES (ABARS)

TIME PERIOD FOR ΔSD's	WPM #1 A-DATE ONE	WPM #2 A-DATE ONE	WPM #1 A-DATE TWO	WPM #2 A-DATE TWO
XA				
1	-.01150	-.02104	-.00119	.02743
2	.01086	.00487	-.00609	-.03728
3	.03459	.03463	.00340	.00011
4	.00532	.00173	-.00595	.03200
5	-.00802	-.00590	.03481	-.00318
6	-.00595	.00079	.02069	.02871
7	.00315	.00254	-.01071	.00944
8	-.01549	-.02667	.00925	.01093
9	.02368	.03071	-.01695	-.04087
10	.00182	.01243	.04648	.01344
11	.01026	.00290	-.03841	.03252
12	.03100	.02677	.03560	.00576
13	-.00504	-.00164	.00761	.00914
14	.02368	.02353	-.02975	-.03422
15	-.00345	-.00114	.00274	.00221
16	.01579	.01647	.00903	.01489
17	.01467	.00261	.01180	.00488
18	.00761	.00757	-.01480	-.00377
19	.01839	.01855	.01304	.01152
20	.02765	.02858	-.00005	.00103
21	.00722	.00846	.03070	-.00498
22	.01384	.01486	-.03407	-.00926
A				
23	.00065	.00196	.00582	.00514
24	-.00786	.00332	-.02152	-.02461
XP				
25	-.00068	-.00550	.01406	.02029
26	.02742	.02367	.01140	.00968
27	.01325	.01259	.00386	.00235
28	.02174	.02250	-.00745	-.01173
29	.03673	.03548	.01060	.01100

With the exception of WPM #2 at A-date one, the percentage of positive cross-sectional averages goes from over half, down to half, and then back to over half again. Although for WPM #2 at A-date one there are no negative ABARS in the announcement (A) regime, the first ABAR immediately thereafter is negative.

The results of hypothesis test (1) [Table Six] also support this profile. The hypothesis that the average differences in the ex-ante regime are equal to zero may be rejected in favor of the alternative hypothesis at the .05 level of significance for both WPM's at A-date one. The reported t-values are 3.05237 and 2.48661 for WPM's #1 and #2 respectively. Although the null hypothesis can not be rejected for the announcement regime for either model at A-date one, it is negative for model #1 and very small (although positive) for model #2. The null may again be rejected (α=.05) for both models in the ex-post regime. The reported t-statistics are 3.14904 and 2.54948. Although at A-date two in each regime for both models the signs of the t-statistics are generally in the predicted directions, the results are not statistically significant. It appears as if the implied standard deviations' sensitivity to the dividend announcement is a function of the option's distance from expiration. There is a detectable smoothing or dampening effect on the model's performance.

The results of hypothesis tests (2) and (3) provide similar confirmation of the information-content-of-dividends hypothesis.

Table Seven summarizes the results of hypothesis test (2). Grand averages were calculated for each regime (consisting of j x t pooled elements). The hypothesis that the grand average of the differences

TABLE SIX
TEST OF HYPOTHESIS (1)
THE PORTFOLIO PROCEDURE†

	A-DATE	EX-ANTE MEAN	STANDARD DEVIATION*	T-STATISTIC**	ANNOUNCEMENT MEAN	T-STATISTIC**	EX-POST MEAN	T-STATISTIC**
WARRANT PRICING MODEL #1	1	.00910	.01398	3.05237**	-.00361	-.36515	.01969	3.14904**
	2	.00305	.02244	.63818	-.00785	-.49481	.00649	.64683
WARRANT PRICING MODEL #2	1	.00825	.01557	2.48661**	.00264	.23982	.01775	2.54948**
	2	.00320	.02034	.73841	-.00973	-.67659	.00632	.69487

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† There are 22, 2, and 5 pooled observations for the XA, A, and XP regimes, respectively, for both WPM's.

* This value represents an unbiased estimate from the ex-ante regime (using the 22 observations prior to announcement) of the common population standard deviation.

** The .05 level of significance for a one-tailed test with 21 degrees of freedom is 1.721. The .05 level for a two-tailed test is 2.080. Significant t-values for a two-tailed test are also double-starred.

in the ex-ante regime is equal to zero may be rejected in favor of the alternative hypothesis at the .05 level of significance for both WPM's at A-date one. The t-values reported are 2.71417 and 2.26551 for WPM's #1 and #2 respectively. Significantly positive changes in the implied standard deviations of stock returns for this regime reflect an uncertainty in market participants concerning the about-to-be-released dividend announcement. Although the null hypothesis could not be rejected in the announcement regime, the sample mean difference in ISD's is definitely lowered in magnitude in both instances and is negative for WPM #1.

Almost immediately after the market assimilates the information contained in the dividend announcement, the ISD differences on average begin to climb back up and resume some "average" level indicating the actual ISD's have resumed increasing after a temporary decline. The t-statistic for both WPM's is significantly positive in this ex-post regime. For WPM's #1 and #2, respectively, the hypothesis of no difference could be rejected at the α=.05 level with t-statistics of 2.44866 and 2.04788. Although the XP results are not consistent with the information arrival model hypothesized in this study, the average behavior evidenced by the ISD differences over the XA and A regimes suggests the dividend announcement does contain some information that the market, on average, finds useful in resolving uncertainty.

The results of hypothesis (2) at A-date two are not as strongly supportive. For both WPM #1 and #2 they are positive, negative, and then positive again, but not significantly so. These results are

TABLE SEVEN
TEST OF HYPOTHESIS (2)
THE GRAND PROCEDURE†

	A-DATE	EX-ANTE MEAN	STANDARD DEVIATION	T-STATISTIC*	ANNOUNCEMENT MEAN	STANDARD DEVIATION	T-STATISTIC**	EX-POST MEAN	STANDARD DEVIATION	T-STATISTIC*
WARRANT PRICING MODEL #1	1	.00910	.09935	2.71417*	-.00361	.10665	-.03005	.01969	.11346	2.44866*
	2	.00305	.13499	.67049	-.00785	.07822	-.89204	.00649	.05540	1.65331
WARRANT PRICING MODEL #2	1	.00825	.10247	2.26551*	.00264	.10472	.21255	.01775	.11595	2.04788*
	2	.00320	.13518	.66616	-.00973	.07758	-1.05707	.00632	.05619	1.50463

† There are 880, 80, and 200 individual observations for the XA, A, and XP regimes, respectively, for WPM #1. Similarly, there are 792, 72, and 180 observations for WPM #2.

* The .05 level of significance for a one-tailed test with $\geq$ 120 degrees of freedom is 1.645 and for a two-tailed test is 1.96. Significant t-values are also starred.

** The .05 level of significance for a one-tailed test with between 70-80 degrees of freedom is 1.66 and for a two-tailed test is 1.99.

partially consistent with the information arrival model's predictions (at least in direction) over the 29 day time horizon.

Table Eight summarizes the results of hypothesis test (3). Individual firm differences were averaged over time for each regime using a GLS procedure. These averages were then pooled into a portfolio where their weights were proportional to the inverse of the variance estimates obtained from the individual firms. For both models at A-date one, the null hypothesis that the average differences in the ex-ante regime is equal to zero may be rejected at the .05 level of significance. The reported t-values are 3.54335 and 3.15112 for WPM's #1 and #2 respectively.

The power of this GLS procedure is more obvious for the A-date two results. For both WPM's, the results are partially consistent with the model's predictions. Although, in general, these results are not statistically significant at the α=.05 level, they are relatively stronger than those obtained under hypothesis (1) or (2).

The information arrival model proposed in this study predicts the ΔSD parameters will on average be positive in the XA regime, negative in the A regime, and zero in the XP regime. Basically, these parameters are found to be (significantly) positive in XA regime, not significantly different from zero in the A regime, and again (significantly) positive in the XP regime. Although these findings are not exactly consistent with the time-series profile hypothesized,

TABLE EIGHT
TEST OF HYPOTHESIS (3)
THE GLS PROCEDURE†

	A-DATE	EX-ANTE MEAN	STANDARD DEVIATION	T-STATISTIC*	ANNOUNCEMENT MEAN	STANDARD DEVIATION	T-STATISTIC*	EX-POST MEAN	STANDARD DEVIATION	T-STATISTIC*
WARRANT PRICING MODEL #1	1	3.24639	5.72163	3.54335*	3.88067	24.47411	.99022	4.56387	14.67441	1.94225
	2	2.02629	6.42739	1.96879	-6.54108	34.24741	-1.19276	5.98476	18.14270	2.06005*
WARRANT PRICING MODEL #2	1	3.18641	5.98232	3.15112*	5.17320	25.08234	1.22018	4.16474	15.31272	1.60905
	2	2.17364	6.34875	2.02550	-9.30970	33.73595	-1.63259	6.09346	18.66031	1.93187

† There are 40 pooled observations for each regime for WPM #1. Similarly, there are 36 pooled observations for each regime for WPM #2.

* For WPM #1, the .05 level of significance for a one-tailed test with 39 degrees of freedom is 1.69 and for a two-tailed test is 2.025. For WPM #2, the .05 level of significance for a one-tailed test with 35 degrees of freedom is 1.69 and for a two-tailed test is 2.03. Significant t-values are also starred.

they are still interpreted as providing evidence supporting the information content of dividends.

Taken together, the results of these three hypotheses suggest the following general implications: for A-date one, that is, the dividend announcement closest to (but before) expiration of the warrant, public disclosure of the announcement in the financial news media did provide the market with useful information that affected the beliefs of the participants regarding the underlying common stock. For A-date two, similar results are suggested, but not statistically confirmed. It should be emphasized that what was being tested here is the information-content-of-dividends hypothesis, per se, not the information-content-of-a-large-change-in-dividends hypothesis. In a vast majority of these cases, the dollar amount of the dividend did not change from the previous period. This implies that investors find the dividend announcement, itself, to be of value. Perhaps a firm's signal of its ability to maintain a stable dividend policy can still be interpreted as a useful disclosure. At the least, it seems market participants find the dividend announcement to contain potentially useful information about the firm and look forward to its announcement in anticipation of resolving some of their uncertainty.

4.5 Empirical Results of Testing for a Size Effect

A complementary set of hypothesis tests is conducted on the sample of firms partitioned into two mutually exclusive subsets. The entire sample of firms is ranked on the basis of absolute market value. This set is divided into two equal groups: small firms and large firms. The relative difference in firm size can be determined by examining the summary table below. Hypotheses (1') through (3') are then carried out independently on each of these two groups. The noticeable result of this entire section analysis is that when statistically significant results surface, they are almost always for the small firm subset.

TOTAL CAPITALIZED MARKET VALUES

	A-DATE	SIZE	NUMBER OF OBSERVATIONS	AVERAGE MARKET VALUE IN MILLIONS (rounded)	RANGE OF MARKET VALUES IN MILLIONS (rounded)
WARRANT PRICING MODEL #1	1	S	20	$60.456	$7.068 to 134.740
		L	20	$987.557	$139.734 to 4342.133
	2	S	20	$64.882	$7.068 to 140.302
		L	20	$1020.866	$177.600 to 4342.133
WARRANT PRICING MODEL #2	1	S	18	$80.147	$22.847 to 140.302
		L	18	$1081.728	$154.450 to 4342.133
	2	S	18	$89.512	$22.847 to 182.500
		L	18	$1114.290	$187.850 to 4342.133

Results of Hypothesis Tests (1'), (2'), and (3')

Plot Two graphs the time-series behavior of the cross-sectional averages (ABARS) for both the small and large firm subsets independently. For both WPM's #1 and #2 at A-date one, the small-firm plots have a substantially more positive (>0.0) concentration of plotted differences than do their large firm counterparts. This is indicative of a greater increase in the ISD's in the XA regime. In addition, there is an observable decline in the time-series profiles of both the small and large-firm ABAR plots at day 25 (the A-date) followed by a rather steep, immediate increase. For A-date two, the plots are less revealing. For both subsets the time-series profiles indicate an average (random) amount of variability across all regimes.

Table Nine reports the ABARS (i.e., cross-sectional averages) for the small and large firm subsets independently.

The summary table below provides the percentage of ABARS from Table Nine that are positive for each WPM at each A-date:

PERCENTAGE OF POSITIVE ABARS

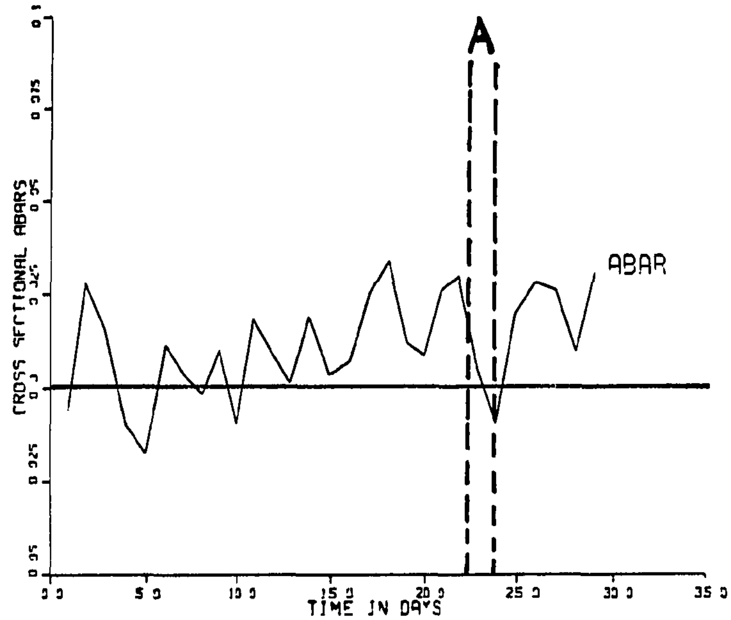
REGIME	WPM #1 A-Date 1 S	WPM #1 A-Date 1 L	WPM #2 A-Date 1 S	WPM #2 A-Date 1 L	WPM #1 A-Date 1 S	WPM #1 A-Date 2 L	WPM #2 A-Date 2 S	WPM #2 A-Date 2 L
XA	$\frac{17}{20}$ = 77%	$\frac{12}{22}$ = 59%	$\frac{14}{22}$ = 64%	$\frac{14}{22}$ = 64%	$\frac{13}{22}$ = 59%	$\frac{12}{22}$ = 55%	$\frac{12}{22}$ = 64%	$\frac{13}{22}$ = 59%
A	$\frac{1}{2}$ = 50%	$\frac{0}{22}$ = 0%	$\frac{1}{2}$ = 50%	$\frac{1}{2}$ = 50%	$\frac{1}{2}$ = 50%	$\frac{1}{2}$ = 50%	$\frac{0}{2}$ = 0%	$\frac{1}{2}$ = 50%
XP	$\frac{5}{5}$ = 100%	$\frac{4}{5}$ = 80%	$\frac{4}{5}$ = 80%	$\frac{3}{5}$ = 60%	$\frac{5}{5}$ = 100%	$\frac{4}{5}$ = 80%	$\frac{4}{5}$ = 80%	$\frac{3}{5}$ = 60%

In each instance, the percentage of positive cross-sectional averages goes from over half, down to half (or zero), and then back to over half ($\geq$ 60%) again. In addition, in each instance in the XA and XP regimes, the small-firm subset's percentage of positive ABARS is relatively greater than or equal to the large-firm subset's percentage. This directionality, however, is not particularly overwhelming and is not examined statistically. It is merely tabulated for descriptive purposes.

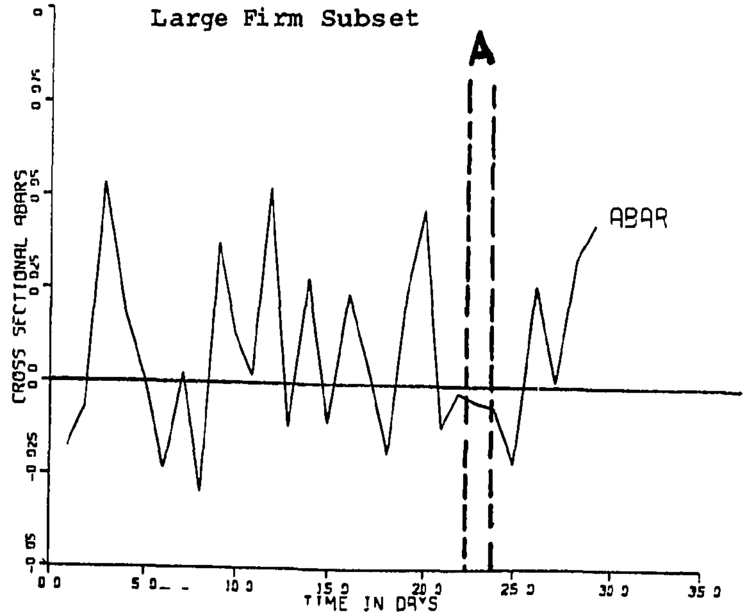
PLOT TWO

Time-Series Profile of Cross-Sectionally Averaged ISD Differences (ABARS) for Small-Large Firm Subsets Plotted in Event Time

WPM #1, A-Date One
Small Firm Subset



WPM #1, A-Date One
Large Firm Subset

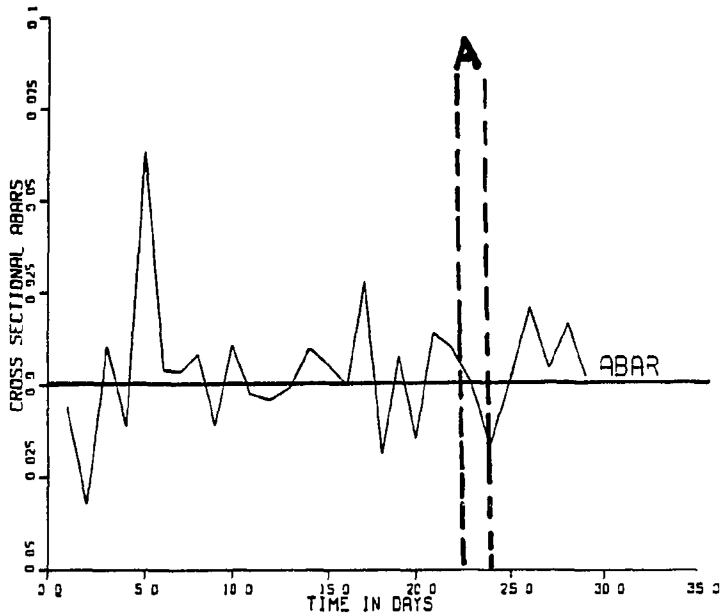


Dividend Announcement Date is Day 24-25 (dashed line).

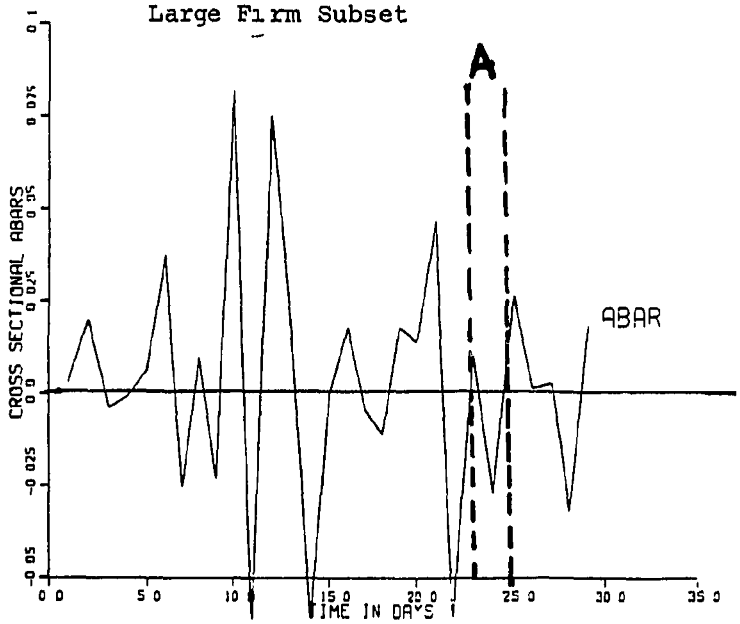
PLOT TWO

Time-Series Profile of Cross-Sectionally Averaged ISD Differences (ABARS) for Small-Large Firm Subsets Plotted in Event Time

WPM #1, A-Date Two
Small Firm Subset



WPM #1, A-Date Two
Large Firm Subset

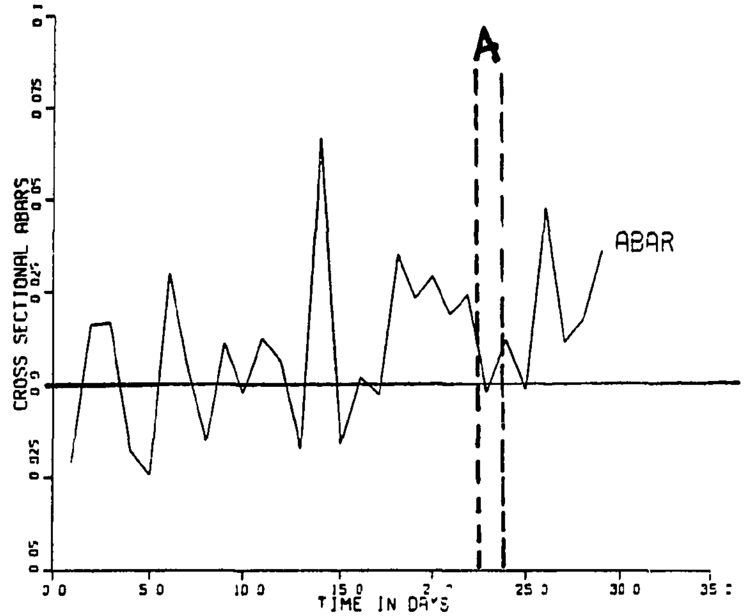


Dividend Announcement Date is Day 24-25 (dashed line).

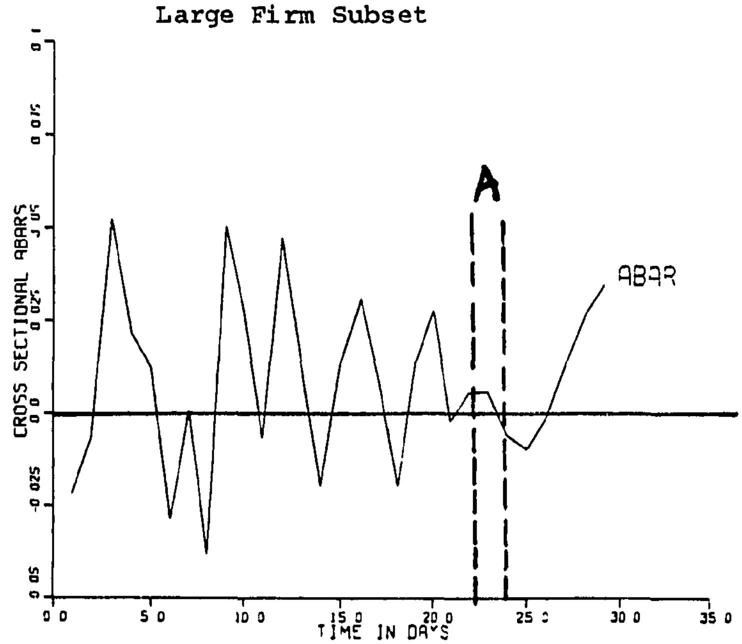
PLOT TWO

Time-Series Profile of Cross-Sectionally Averaged ISD Differences (ABARS) for Small-Large Firm Subsets Plotted in Event Time

WPM #2, A-Date One
Small Firm Subset



WPM #2, A-Date One
Large Firm Subset

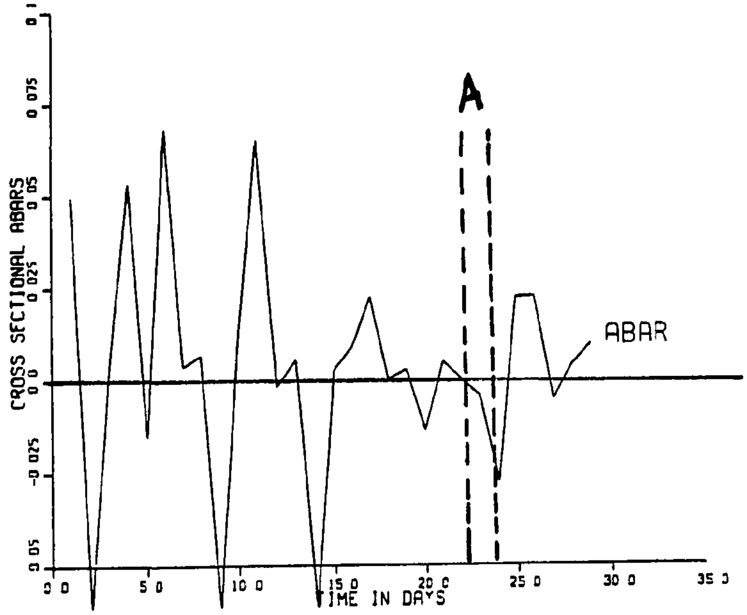


Dividend Announcement Date is Day 24-25 (dashed line).

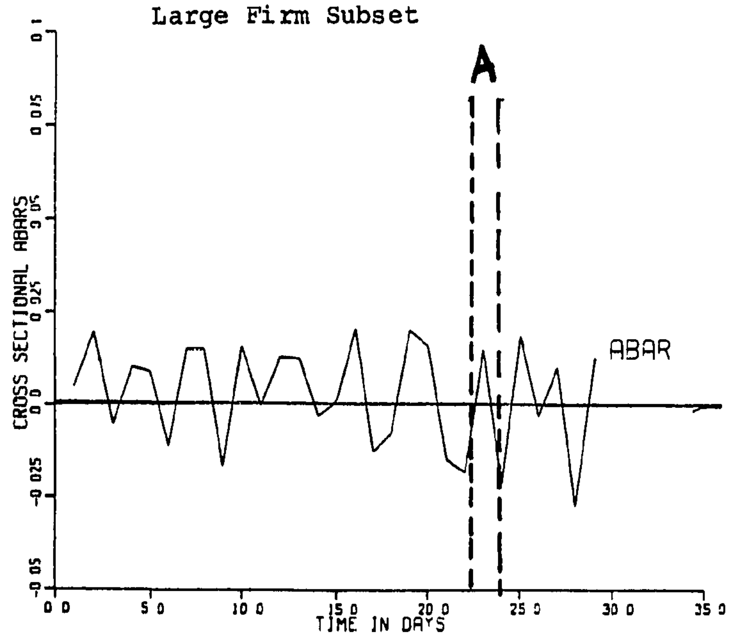
PLOT TWO

Time-Series Profile of Cross-Sectionally Averaged ISD Differences (ABARS) for Small-Large Firm Subsets Plotted in Event Time

WPM #2, A-Date Two
Small Firm Subset



WPM #2, A-Date Two
Large Firm Subset



Dividend Announcement Date is Day 24-25 (dashed line).

TABLE NINE
CROSS-SECTIONAL AVERAGES (ABARS) FOR SMALL VS. LARGE FIRMS
A-DATE ONE

TIME PERIOD FOR ΔSD's	WPM #1 SMALL FIRM SUBSET	WPM #1 LARGE FIRM SUBSET	WPM #2 SMALL FIRM SUBSET	WPM #2 LARGE FIRM SUBSET
XA				
1	-.00582	-.01717	-.02069	-.02139
2	.02810	-.00638	.01629	-.00655
3	.01571	.05348	.01681	.05244
4	-.00929	.01994	-.01786	.02132
5	-.01751	.00146	-.02431	.01251
6	.01146	-.02336	.03011	-.02853
7	.00358	.00273	.00431	.00077
8	-.00141	-.02957	-.01534	-.03800
9	.00993	.03743	.01121	.05021
10	-.00953	.01318	-.00221	.02708
11	.01844	.00209	.01248	-.00668
12	.00976	.05225	.00633	.04721
13	.00134	-.01134	-.01725	.01397
14	.01907	.02829	.06686	-.01980
15	.00344	-.01035	-.01606	.01378
16	.00736	.02423	.00212	.03082
17	.02521	.00414	-.00286	.00809
18	.03384	-.01861	.03489	-.01975
19	.01207	.02471	.02316	.01393
20	.00854	.04676	.02929	.02787
21	.02599	-.01155	.01902	-.00210
22	.02981	-.00213	.02416	.00556
A				
23	.00599	-.00470	-.00211	.00604
24	-.00939	-.00632	.01246	-.00582
XP				
25	.01986	-.02121	-.00135	-.00965
26	.02827	.02658	.04809	-.00076
27	.02592	.00058	.01142	.01377
28	.00981	.03368	.01808	.02692
29	.03042	.04303	.03618	.03477

TABLE NINE
CROSS-SECTIONAL AVERAGES (ABARS) FOR SMALL VS. LARGE FIRMS
A-DATE TWO

TIME PERIOD FOR ΔSD's	WPM #1 SMALL FIRM SUBSET	WPM #1 LARGE FIRM SUBSET	WPM #2 SMALL FIRM SUBSET	WPM #2 LARGE FIRM SUBSET
XA				
1	-.00575	.00336	.04949	.00536
2	-.03230	.02012	-.09420	.01963
3	.01045	-.00365	.00524	-.00502
4	-.01128	-.00062	.05345	.01055
5	.06323	.00639	-.01531	.00896
6	.00401	.03738	.06813	-.01072
7	.00386	-.02527	.00364	.01524
8	.00854	.00996	.00671	.01516
9	-.01084	-.02306	-.06541	-.01634
10	.01094	.08202	.01076	.01611
11	-.00232	-.07451	.06509	-.00005
12	-.00398	.07518	-.00179	.01330
13	-.00041	-.01562	.00542	.01287
14	.01007	-.06956	-.06563	-.00281
15	.00559	-.00010	.00281	.00161
16	.00007	.01800	.00904	.02074
17	.02821	-.00461	.02221	-.01245
18	-.01857	-.01104	-.00003	-.00751
19	.00797	.01811	.00280	.02025
20	-.01417	.01407	-.01374	.01581
21	.01430	.04710	.00468	-.01464
22	.01050	.07864	-.00018	-.01835
A				
23	.00096	.01068	-.00461	.01489
24	-.01595	-.02709	-.02784	-.02137
XP				
25	.00160	.02652	.02204	.01854
26	.02124	.00157	.02232	-.00297
27	.00482	.00289	-.00561	.01031
28	.01704	-.03193	.00381	-.02726
29	.00273	.01846	.00922	.01278

Table Ten reports the results of hypothesis test (1'). For WPM #1 at A-date one, the small firm ex-ante mean is significantly different from zero at the $\alpha=.05$ level. Its t-value is 3.388. The corresponding large firm ex-ante mean is not significant with a t-value of 1.55684. Both subsets report a negative t-statistic for the announcement regime, neither of which is significant. However again for the ex-post regime, the small firm mean is significantly different from zero with a t-value of 3.69115 and the large firm mean is not (t-value=1.49844). Analogous, though slightly weaker results are reported for WPM #2 at A-date one. To a large extent, this directional pattern of results is repeated throughout Table Ten, however, the results are not powerful enough to allow rejection of the nulls.

Table Eleven reports the results of hypothesis test (2'). In three instances the null hypothesis that the regime-specific means equal zero may be rejected. All three of these times are for the small firm subset. For WPM #1 at A-date one, the reported t-values for the small firm subset go from 3.313 down to -.1222 and then back up to 2.869 for the XA, A, and XP regimes, respectively. Roughly, the same pattern is observed for the corresponding large firm subset, but the results are insignificant. Similarly, for WPM #2 at A-date one, the small firm t-values are 1.924, .367, and 2.048, respectively. Analogously, the corresponding large firm results are 1.404, .055, and .967.

TABLE TEN

TEST OF HYPOTHESIS (1')

PORTFOLIO PROCEDURE ON SMALL/LARGE FIRM SUBSET

	A-DATE	FIRM SIZE	EX-ANTE MEAN	STANDARD DEVIATION	T-STATISTIC*	ANNOUNCEMENT MEAN	T-STATISTIC*	EX-POST MEAN	T-STATISTIC*
WARRANT PRICING MODEL #1	1	S	.01000	.01353	3.38800*	-.00170	-.17361	.02286	3.69115*
	1	L	.00819	.02410	1.55684	-.00551	-.31590	.01653	1.49844
	2	S	.00355	.01815	.89634	-.00750	-.57095	.00948	1.14108
	2	L	.00256	.04012	.29199	-.00821	-.28275	.00350	.19059
WARRANT PRICING MODEL #2	1	S	.00820	.02184	1.72122	.00517	.32708	.02249	2.24968*
	1	L	.00831	.02460	1.54742	.00011	.00618	.01301	1.15538
	2	S	.00242	.03860	.28698	-.01622	-.58060	.01036	.58635
	2	L	.00399	.01277	1.43028	-.00324	-.35056	.00228	.39006

* The .05 level of significance for a one-tailed test with 21 degrees of freedom is 1.721. The .05 level for a two-tailed test is 2.08.

Significant t-values are also starred.

Again, the regularity generally demonstrated in Table Eleven is the relatively greater t-values of the small firm group vis-à-vis the large firm group. In addition, the relative mean-changes across regimes are not as dramatic for the large firms as they appear to be for the small firms. The dividend announcement seems to impact more on the smaller firm subset.

Table Twelve reports the results of hypothesis test (3'). In six instances the null hypothesis that the mean is equal to zero may be rejected. Some of these t-values have signs consistent with the information-arrival model's predictions. Five of these six are for the small firm subset.

4.6 Empirical Results of Hypothesis Tests (4) and (5)

This set of hypotheses tests to see whether the ΔSD parameters were significantly different from one another across regimes. A two-way ANOVA procedure is utilized which facilitates a comparison of each time regime by firm size, allowing hypothesis test (4) to be examined in conjunction with hypothesis test (5). In each case, the samples are assumed to be random draws from their respective populations and independent from one another.

Table Thirteen reports the results of the joint test of hypotheses (4) and (5). This table presents comparisons for small versus large firms matched by regime in event time. A two-way ANOVA is used to examine these hypotheses. The purpose of this set of comparisons is to see whether the information-arrival process is functionally related to firm size (i.e., market structure).

TABLE ELEVEN

TEST OF HYPOTHESIS (2')

GRAND PROCEDURE ON SMALL/LARGE FIRM SUBSETS

	A-DATE	FIRM SIZE	EX-ANTE MEAN	STANDARD DEVIATION	T-STATISTIC*	ANNOUN. MEAN	STANDARD DEVIATION	T-STATISTIC**	EX-POST MEAN	STANDARD DEVIATION	T-STATISTIC***
WARRANT PRICING MODEL #1	1	S	.01000	.06327	3.31287*	-.00170	.08706	-.12219	.02286	.07927	2.86897***
	1	L	.00819	.12545	1.36749	-.00551	.12313	-.27935	.01653	.13943	1.17964
	2	S	.00355	.07408	1.00411	-.00750	.05655	-.82777	.00948	.04994	1.88946
	2	L	.00256	.17595	.30435	-.00821	.09507	-.53897	.00350	.06022	.57867
WARRANT PRICING MODEL #2	1	S	.00820	.08471	1.92425	.00517	.08333	.36728	.02249	.10356	2.04828***
	1	L	.00831	.11759	1.40419	.00011	.12238	.00532	.01301	.12696	.96679
	2	S	.00242	.18256	.26317	-.01622	.05031	-1.90780	.01036	.05660	1.72920
	2	L	.00399	.05675	1.39626	-.00324	.09707	-.19758	.00228	.05558	.38736

* The .05 level of significance for a one-tailed test with $\geq$ 120 degrees of freedom is 1.645 and for a two-tailed test is 1.96.

** The .05 level of significance for a one-tailed test with between 35-40 degrees of freedom is 1.69 and for a two-tailed test is 2.03.

*** The .05 level of significance for a one-tailed test with between 90-100 degrees of freedom is 1.66 and for a two-tailed test is 1.99.

Significant t-values are also starred.

TABLE TWELVE
TEST OF HYPOTHESIS (3')
GLS PROCEDURE ON LARGE/SMALL FIRM SUBSETS

	A-DATE	FIRM SIZE	EX-ANTE MEAN	STANDARD DEVIATION	T-STATISTIC*	ANNOUNC. MEAN	STANDARD DEVIATION	T-STATISTIC*	EX-POST MEAN	STANDARD DEVIATION	T-STATISTIC*
WARRANT PRICING MODEL #1	1	S	2.97581	3.66494	3.53928*	6.30129	24.23520	1.13334	7.24880	10.33707	3.05665*
	1	L	3.51698	7.20389	2.12804*	1.46006	24.47246	.26006	1.87894	17.58994	.46561
	2	S	3.17432	8.32041	1.66296	-9.59579	43.26175	-.96684	11.19523	21.23605	2.29792*
	2	L	.87826	3.27986	1.16720	-3.48637	21.34311	-.71202	.77429	12.37129	.27281
WARRANT PRICING MODEL #2	1	S	2.72464	3.70063	3.03569*	9.43698	23.87135	1.62997	6.67814	10.65667	2.58379*
	1	L	3.64818	7.57994	1.98442	.90946	25.53520	.14685	1.65135	18.51382	.36776
	2	S	2.93064	8.35641	1.44600	-15.26345	39.75900	-1.58286	10.96132	22.49170	2.00939
	2	L	1.41663	3.10445	1.88146	-3.35589	24.99109	-.55367	1.22559	11.96440	.42236

* For WPM #1, the .05 level of significance for a one-tailed test with 19 degrees of freedom is 1.729 and for a two-tailed test is 2.093. For WPM #2, the .05 level of significance for a one-tailed test with 17 degrees of freedom is 1.74 and for a two-tailed test is 2.11. Significant t-values are also starred.

TABLE THIRTEEN
JOINT TEST OF HYPOTHESES (4) AND (5)
PRINCIPAL TWO-WAY ANOVA FINDINGS FOR TIME BY SIZE

	A-DATE	SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROBABILITY *
WARRANT PRICING MODEL #1	1	TIME	2	.034	.017	1.627	.197
		SIZE	1	.002	.002	.205	.651
		TOTAL MAIN EFFECTS	3	.036	.012	1.153	.326
		2-WAY INTERACTION OF TIME AND SIZE	2	.001	.000	.040	.960
		TOTAL EXPLAINED	5	.037	.007	.708	.617
		WITHIN GROUP (RESIDUAL)	1154	12.168	.011		
		TOTAL	1159	12.205	.011		
	2	TIME	2	.012	.006	.399	.671
		SIZE	1	.001	.001	.066	.798
		TOTAL MAIN EFFECTS	3	.013	.004	.288	.834
		2-WAY INTERACTION OF TIME AND SIZE	2	.001	.001	.035	.966
		TOTAL EXPLAINED	5	.014	.003	.187	.968
		WITHIN GROUP (RESIDUAL)	1154	17.136	.015		
		TOTAL	1159	17.150	.015		
WARRANT PRICING MODEL #2	1	TIME	2	.017	.008	.759	.468
		SIZE	1	.001	.001	.085	.771
		TOTAL MAIN EFFECTS	3	.018	.006	.535	.659
		2-WAY INTERACTION OF TIME AND SIZE	2	.004	.002	.160	.852
		TOTAL EXPLAINED	5	.021	.004	.385	.859
		WITHIN GROUP (RESIDUAL)	1038	11.522	.011		
		TOTAL	1043	11.543	.011		
	2	TIME	2	.014	.007	.458	.632
		SIZE	1	.000	.000	.008	.927
		TOTAL MAIN EFFECTS	3	.014	.005	.308	.819
		2-WAY INTERACTION OF TIME AND SIZE	2	.006	.003	.212	.809
		TOTAL EXPLAINED	5	.020	.004	.270	.930
		WITHIN GROUP (RESIDUAL)	1038	15.468	.015		
		TOTAL	1043	15.489	.015		

* The α-level of significance for the F-RATIO.

Table Thirteen presents the principal findings of a two-way ANOVA conducted on the ΔISD's for regime-time by firm size. Although none of the effects (main or interaction) are significant at the α=.05 level, certain trends are still visible. In each instance, the main effect of time period (XA, A, or XP) is relatively more significant than the corresponding effect of firm size. In addition, the two-way interaction effect of time and size is noticeably unimportant in each case. The ANOVA results are not powerful enough to draw any statistical inferences.

CHAPTER 5

CONCLUSIONS

5.1 Summary and Conclusions

The objective of this study was to provide empirical evidence concerning the information content of the dividend announcement by employing a different "measurement tool." This tool seemed particularly attractive because it provided a method, based on an alternative equilibrium asset pricing relation, to scrutinize the implied variability of the security price formation process. The results from this study will be useful in assessing the response of market participants to one type of management signal. It is hoped that this work may supplement the set of accounting research studies concerned with the relationship (i.e., statistical dependency) between accounting disclosures and security returns.

In addition, the issue of firm size was examined. The purpose of this feature of the analysis was to provide information about the "structure" of the market and insight into potentially different "levels" (or degrees) of efficiency.

The option pricing model has facilitated the theoretical treatment of a wide variety of contingent claims such as convertible bonds, rights, or pensions. In this study, the OPM was adapted to accommodate the idiosyncrasies of warrants. By using the current stock price and related warrant price in a warrant pricing model, common stock variability could be implied. It was conjectured that examination of the time-series behavior of these implied standard deviations attendent to a dividend announcement could reveal an increase in security price variability, even though the actual dividend announcement may have had no observable effect on average stock price. This hypothesized increase in variability could be taken as an indication of the information content of the announcement. Most previous empirical tests of this information-content-of-dividends hypothesis, as well as other dividend hypotheses (e.g., the wealth-redistribution hypothesis) were ex-post in nature. This study employed an ex-ante methodology staged in event-time that focused on the aggregate market's response in anticipation of the announcement. The power of most previous tests of this phenomenon was predicated on a significantly large change in dividend behavior. This study did not place so restrictive a condition on its sample. Consequently, a salient feature of the results of the current study is that they are more applicable to firms' dividend signals in general.

Two versions of the OPM model were adjusted and employed in this study. The Black-Scholes [1973] version assumes asset trading is continuous; that is, an investor's position in the hedged portfolio can be continuously revised. The expected return from this hedged position is the risk-free rate. Market expectations do not enter into the price formation process. The Lee, Rao, Auchmuty [1981] version allows asset trading to take place at discrete points in time (i.e., the hedge is not maintained continuously). Consequently, market expectations surface in the equilibrium pricing relation and a risk neutral valuation relationship is not guaranteed. Both of these versions were adjusted to accommodate dividend and capital structure complications introduced with warrants. This study did not compare the performance or predictive ability of these competing models against one another. That task requires a significantly larger data base and should be carried out on actively traded stock options (at least first). However, certain useful insights can be gained by examining the relative performances of the two models. Individual firm plots comparing the ΔSD behavior demonstrate that the discrete version (LRA) of the OPM conforms very closely to the traditional, continuous version (B-S). When the models' time-series profiles were plotted along side one another, their profiles (i.e., the shape of their plots) were almost identical. In addition, the pattern of empirical results that were reported was quite similar for the competing models. Generally, when statistical significance was found for the B-S model for a given announcement in a particular regime, it was usually present for the LRA model. Similarly, when non-significant t or F values occurred, they generally surfaced in analogous regimes for both models. Although these descriptive results were only evidenced by casual observation, they suggested the models actually perform quite comparably. Addition of the two expectation parameters required for the discreet version did not appear to enhance or detract from that model's performance.

The option pricing model has proven to be rather sensitive to one of its parameters, time-to-expiration. Consequently, this study examined at most the final two dividend announcements prior to expiration of the warrant. Merton [1973] has demonstrated that the OPM is still robust when the stock return variance rate is changing as a known function of time. Perhaps the time period surrounding the dividend announcement process approximates that condition.

The model of information arrival proposed in this study predicted that the behavior of common stock return variances in the time periods prior to, during, and immediately after announcement of a dividend should be characterized as increasing, decreasing, and constant, respectively. Unlike previous applications of this option methodology to information-content issues, this study incorporated a pooling procedure staged in event-time that facilitated aggregation of the firm-specific data. Portfolios were constructed for three time-series regimes that allowed the information-arrival process to be examined. Presuming the disclosure was of informational value to the market participants (i.e., had information content), this specification suggests the time-series behavior of the ISD differences should be positive, negative, and zero for these respective regimes.

For A-date <u>one</u>, the empirical results of this study indicate that, on average, the ISD differences were positive for the ex-ante regime, and again positive for the ex-post regime. For the announcement regime, the ISD differences were not significantly different from zero.

Although these results were not entirely consistent with the information-arrival model's predictions, they still may be interpreted as providing support for the hypothesis of information content. In 3 out of 4 cases, there appeared to be a noticeable (although not statistically significant) decline in the implied variability of the underlying stock at announcement. This suggests that the announcement may have been useful in resolving (at least some of) the uncertainty surrounding its anticipated disclosure. Dividend announcements, like quarterly earnings announcements, occur at approximately the same times each year for any particular firm. For this sample of firms, market agents knew in advance that a major information release would be made at a specific point in time. What they did not know was the content of that about-to-be-released disclosure. The significantly positive t-values in the ex-ante regime at A-date one could be interpreted as reflecting this underlying uncertainty. This study examined the information content of dividends, per se, not changes in dividends. These results indicate there is significant uncertainty surrounding the dividend announcement even for firms with a relatively stable dividend history.

Although the ISD differences for the announcement regime were not, on average, significantly negative, they were always relatively less than the ex-ante differences. These empirical test results were consistent with the hypothesis that warrant prices reflect investors' anticipation of the forthcoming dividend announcements. Perhaps they were useful in resolving some of the uncertainty concerning the firm's expected performance. The market, in the aggregate, seemed to interpret the signal as connoting some amount of new information.

Prior accounting research (e.g., May [1971]) had indicated that certain accounting reports and disclosures are, on average, followed by increases in stock price variability, and the (significantly) positive ex-post t-values generally reported in this study are consistent with that finding. Almost immediately after the information is assimilated into the market, the ISD differences again become significantly positive. Perhaps the particularly short-term documented reduction of variability at announcement indicates that new uncertainty concerning some future (different) accounting release or institutional result is affecting the price formation process.

If a second informative disclosure occurs after the date of the test event but before the expiration of the warrant, it is highly plausible that the increase in variability associated with the second event could significantly exceed that of the first event. Examining multiple disclosures and/or scaling the relative magnitudes of effect over time are typical problems encountered in an event study. It is difficult to assess the effect these complications had on this option methodology. More research of a similar nature is needed to evaluate the usefulness and power of this new "measurement tool."

For A-date <u>two</u>, the empirical results were not as significant. For both WPM's, the results of this study indicate that, on average, for the ex-ante, announcement, and ex-post regimes, the ISD differences were not significantly different from zero. Patell and Wolfson [1979] noted a similar dampening effect with annual earnings announcements. It appears as if this type of methodology is particularly sensitive to the warrant's proximity to expiration. The technique does not readily apply to all disclosures or events throughout a warrant's useful life. Calculation of this implied standard deviation statistic is constrained to situations which are relatively close to the warrant's expiration. A sufficiently long time-to-expiration parameter produces a smoothing or dampening effect on the model's performance (see section 5.2 on limitations) which makes detection of a time-linked information-content issue infeasible.

An analogous set of tests was carried out on the sample dichotomized into two mutually exclusive subsets formed on the basis of firm size (i.e., total market value). The pattern of results was quite similar. The major conclusion of this set of tests was that on average the values obtained from the statistical tests were relatively stronger for the small-firm subset, but in general, were not significantly different from the large-firm results. It would be inappropriate to rationalize or explain these differences due to their lack of statistical significance. Lastly, a two-way ANOVA was conducted to facilitate testing of a time period treatment condition, established by the XA, A, and XP time-series regimes in conjunction with a firm size treatment condition, established by a relative market value dichotomy. No main (or interaction) effects were significant at the α=.05 level.

5.2 Limitations and Extensions of the Study

Limitations

Any reasonably complex empirical study involves certain strategic compromises. Incomplete or conflicting data sources, imperfect or simplistic model specification, unrealistic or overly stringent operating assumptions, the omission of critical variables or key considerations, among others, all compromise the study to some extent. The test, however, of a useful empirical study is whether or not inferences can be drawn or insights made from its results.

The entire research design in this study is developed around the output of the equilibrium option pricing model. That model, as well as variations of that model, has proved to be quite robust under certain conditions. In this study, the model's sensitivity to the time-to-expiration parameter had a significant effect on the power of the statistical tests that were utilized. The model clearly performed best in some relevant time range that was a function of the underlying warrant's distance from maturity. If the dividend announcement was too close to the expiration of the warrant, the model seemed overly sensitive to slight changes in the stock and/or warrant prices. If the announcement was too far from the warrant's expiration, the model was reasonably insensitive to stock and warrant price movement. Patell and Wolfson [1981] took note of this condition commenting,

> "...the form of the equation (for the average variance to expiration) makes it apparent that the anticipated information effect will be strongest when the interval between observation and expiration is small, that is, when the announcement and preceding test dates are close to the option expiration date." (p. 441)

This phenomenon appeared to smooth out or dampen the effect of the dividend announcements at A-date two. This suggests application of this type of tool is most appropriate in situations where the firm issues a disclosure reasonably close to the expiration of the warrant and the market is aware of the approximate release date of the announcement but uncertain as to its "content". As long as the disclosure is at least 30 days but not more than approximately 125 days prior to the warrant's expiration, the model appears reasonably robust. Notice, this constraint on the model's application is more critical when it is adapted to relatively long-lived contingent contracts like warrants. Given a specific disclosure event of interest, it is likely that a sufficient number of actively traded options, reasonably close to expiration, can be found in future studies to bracket the announcement date.

A potential source of measurement error is introduced in an option study when non-synchronous trading exists. This bias surfaces, for example, when the warrant stops trading at noon and the stock continues to trade until the market closes. This type of measurement error is also aggravated in a thin or low volume market. Inappropriate matching (in time) of stock price and related warrant price in the OPM introduces unsystematic noise into the measurement process. It also exerts an influence on the hedging strategy temporarily upsetting the status of the equilibrium model.

Another implementation problem in this particular empirical study was the sample size. Even though this study included every actively traded warrant that met the sample selection criteria, there were still relatively few firms. This small sample size problem was accentuated when the firm size issue was examined and the sample was split in half. Insufficient sample size clearly contributed to a lack of power in the testing procedures. In addition, detecting a differential reaction in implied variability based on firm size was further exacerbated by the fact that the "large" firm subset in these tests was not particularly large by overall (NYSE) market standards.

An additional interpretational qualification must be made concerning these results. Because the time-series pattern of the ΔSD's that was generally observed was not totally consistent with the profile conjectured in the information arrival model, alternative plausible explanations of the results were offered.

As in any event study, it is particularly difficult to control for exogenous (i.e., outside the study) factors which affect the equilibrium price formation process of a specific firm. Although an attempt was made to exclude any firm whose dividend announcement interacted with or was contaminated by contemporaneous disclosures, unpublished, informal, or insider announcements could certainly drive stock price or variability changes. Alternatively, the temporary pause documented between the generally positive XA and XP regimes (i.e., at announcement) could be an anomalous artifact of the option pricing methodology.

In spite of these limitations the empirical results of this study (at least for the final dividend announcement prior to expiration) were consistent with the hypothesis that warrant prices and the implied variability of their underlying stock returns reflect investors' anticipation of the forthcoming dividend announcement.

Extensions

This study has stimulated a variety of implications for future accounting and finance research which may incorporate the option methodology.

This option methodology seems to be a particularly attractive type of empirical method because, "the anticipated information content approach allows one to separate the expected information content of an accounting system from the realized price response to a particular signal from that system," (Patell and Wolfson [1981; p. 456]). In the context of dividends, perhaps the dividend signal is not perceived, on average, by market participants as providing useful information in an ex post sense. However, anticipation of that signal, and the potential that it will be of use in valuing the firm, can be reflected, in an ex ante sense, by an increase in the stock's implied variability. To the extent this variability is reduced by the dividend announcement, evidence is provided that the disclosure was, in fact, of use in valuing the asset. Actual signal realization may or may not drive a shift in the firm's mean stock price, but it is anticipation of that signal that drives an increase in its variance.

Accounting events whose approximate announcement date can be predicted are all candidates for this type of study. This would include routine accounting disclosures made periodically by the firm like interim announcements or registered filings as well as institutional or accounting policy pronouncements.

Another option-related extension suggested by this research would be to compare the performance and predictive ability of the two versions (i.e., the continuous and the discrete) of the option pricing model. Perhaps the gain in generality that is obtained in the discrete OPM by allowing market expectations to surface in the pricing relation, is more than offset by the incremental costs incurred by adding more degrees of freedom to the measurement process. This is an empirical issue that should be addressed.

Lastly, as this study indicated, analytical as well as empirical work is needed to help refine the characterization of the stock's time-series variance profile and its relationship to expiration of the option as well as disclosure events. Refinement of this specification will be useful in modeling the variance's behavior in other option-based research.

This type of innovative methodology seems to provide a particularly attractive way to scrutinize the interrelationship between the option and stock markets. It facilitates the examination of numerous accounting-related signals. However, it must be emphasized that this type of research does not have as its objective the specification of a profitable trading rule or the delineation of any particular accounting policy position.

Another limitation of this (type of) research, which is not nearly so visible as its methodological shortcomings, occurs when the results are misinterpreted. Proponents of the efficient market hypothesis have suggested that market studies provide one type of objective criterion that can be used by various institutions in their policy-making functions. As Beaver and Dukes [1972] asserted:

> The (accounting) method which provides earnings numbers, conditional upon the prediction models, having the highest association with security prices, is the most consistent with the information that results in an efficient determination of security prices. Subject to (certain) qualifications, it is the method that ought to be reported. (p. 321)

Essentially, Beaver and Dukes are suggesting that this methodology provides one criterion against which policy-making institutions (e.g., the FASB) can evaluate or select accounting procedures and disclosure requirements.

However, the domain of policy-making is a particularly nebulous one. In that any discussion of the security markets necessarily invokes discussions of resource allocation, comparisons of interpersonal utility, informational externalities, and ultimately, social policy decision, an obvious limitation of API- or CAR-type information content studies applies equally forcefully to this option methodology. As Gonedes and Dopuch [1974], among others, have warned: (paraphrased)

> Residual analysis generally can not resolve the question of finding the socially optimal accounting alternative.

The purpose of this research is not to prescribe accounting methods nor make normative statements about what should or should not be reported to the public. Stock-holders are obviously interested in the cash flow from dividends. However, whether or not that signal affects stock prices is an independent issue. The purpose of this research is simply to examine that information-content-of-dividends issue from a different perspective and to perhaps gain a useful insight into the efficiency controversy.

APPENDIX A

Model #1 (Black-Scholes)

(a) Option Pricing Model:

$$C_i = S_i \cdot N\{d_1\} - Xe^{-r_f T} \cdot N\{d_2\} \qquad \text{where,}$$

$$d_1 = \frac{\ln(\frac{S_i}{X}) + (r_f + \frac{1}{2}\sigma^2)T}{(\sigma\sqrt{T})} \qquad \text{and}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

with C $\equiv$ Call (option) price for a single share of stock (i.e., the current option value)
S $\equiv$ Stock price (current; i.e., at time point 0)
X $\equiv$ Exercise price of the option
e $\equiv$ The base of the natural logarithms
T $\equiv$ Time (remaining) until expiration of the option
r_f $\equiv$ Continuous risk-free rate of interest per period of time (T)
σ $\equiv$ Standard deviation of continuous returns on stock per unit of time (T)
$N\{\bullet\}$ $\equiv$ Cumulative standard normal distribution (density) function of $\{\bullet\}$

(b) Assumptions: (Black and Scholes [1973]; p. 640)

(i) The short-term (i.e., risk free) interest rate is known and constant through time.

(ii) The stock price is continuous. That is, it follows a random walk in continuous time with a variance rate proportional to the square of the stock price. This implies that the distribution of possible stock prices at the end of any finite interval is lognormal and the variance rate of return on the stock is constant.

(iii) The stock pays no dividends or other distributions.

(iv) The option can only be exercised at the terminal date of the contract (i.e., at expiration). That is, the option is "European."

(v) Transaction costs and taxes are zero.

(vi) It is possible to borrow any fraction of the price of a security to buy it or hold it, at the short-term interest rate.

(vii) There are no penalties for short sales.

(viii) The market operates continuously.*

(c) Beta:

$$\beta_c = \left\{[\frac{S}{C}]N(d_1)\right\}\beta_i$$

(d) Hedge Ratio:

$$(\frac{\partial C}{\partial S})^{-1} = \frac{1}{N(d_1)}$$

Model #2 (Black-Scholes, adjusted for dividends (Merton))

(a) Model:

$$C_i = e^{-yT} \cdot S_i \cdot N\{d_1\} - Xe^{-r_f T} \cdot N\{d_2\}$$

where,

$$d_1 = \frac{\ln(\frac{S_i}{X}) + (r_f - y + \frac{1}{2}\sigma^2)T}{(\sigma\sqrt{T})} \qquad \text{and}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

with $y \equiv$ Constant, known, continuous dividend rate (i.e., yield).

All other notation remains as it was before. Note that since dividends are paid this equation may not be applied to value American call options, because there is always some positive probability that such options will be prematurely exercised. (See Merton [1973])

(b) Assumptions are the same as those in Model #1 except, of course, (iii) has been dropped out.

(c) Beta:

$$\beta_c = \left\{[\frac{S}{C}]e^{-yT}N(d_1)\right\}\beta_i$$

---

* Smith [1976; p. 4] explicitly stated this assumption.

(d) Hedge Ratio:

$$\left(\frac{\partial C}{\partial S}\right)^{-1} = \frac{e^{yT}}{N(d_1)}$$

Note: Merton's adjustment for dividends necessitates both the β_C and H.R. be re-specified.

Model #3 (Lee, Rao, Auchmuty)

(a) Model:

Lee, Rao, and Auchmuty demonstrate in Theorem II that, in equilibrium, in a log-normal securities market, the value of a call option (C) with exercise price (X), and time to expiration (T) is given by: [p. 84, equation (8)]:

$$C_i = S_i\ [1 - \theta]\ N(d_1^*) - X\exp\ (-r_f T) N(d_2^*)$$

where

$$\theta = \left\{\frac{\exp(\mu_i T) - \exp(r_f T)}{\exp(r_f T)}\right\}\Phi$$

and

$$\Phi = \frac{[N(d_3^*) - N(d_1^*)]\exp(\sigma_{im} T) + N(d_2^*) - N(d_4^*)}{N(d_1^*)[\exp(\sigma_{im} T) - 1]}$$

with $d_1^* = (\sigma_i\sqrt{T})^{-1}[\ln(S_i/X) + (\mu_i + 1/2\sigma_i^2)T]$

$$d_2^* = d_1^* - \sigma_i\sqrt{T}$$

$$d_3^* = (\sigma_i\sqrt{T})^{-1}[\ln(S_i/X) + (\mu_i + 1/2\sigma_i^2 + \sigma_{im})T]$$

$$d_4^* = d_3^* - \sigma_i\sqrt{T}$$

All other notation remains the same, except:

μ_i ≡ Expected logarithmic return on the underlying asset (i.e., stock).

σ_{im} ≡ The logarithmic covariance of its return with the market return.

(b) Assumptions:

Essentially, they make the same assumptions [see LRA, p. 81, (a)-(d)] as Black and Scholes, except they assume that:

(i) Asset price changes follow a stationary random walk and asset returns are lognormally distributed. That is,

$\ln(R_i)(t) \sim N[(\mu_i - 1/2\sigma_i^2)t,\ \sigma_i^2 t]$

where $R_i(t) \equiv \frac{S_i(t)}{S_i(o)} \equiv \exp[r_i(t)] \equiv$ the random gross rate of return on the i^{th} asset during period t.

(ii) Trading is discrete and each investor maximizes his expected utility of end-of-period wealth. Each prefers more wealth to less, is risk averse, and has a preference for positive skewness.

(c) Beta:

$$\beta_C = \left\{[\frac{S}{C}]N(d_1^*)[1+\Phi]\right\}\beta_i$$

(d) Hedge Ratio:

$$(\frac{\partial C}{\partial S}^{-1}) = \left(N(d_1^*)[1+\Phi]\right)^{-1}$$

APPENDIX B

To compare betas:

Observe that the expected excess return for an option (C) on the underlying stock (S) can be expressed as:

$$E(R_C) - R_f = \left\{ [\frac{S}{C}] \cdot [\frac{\partial C}{\partial S}] \right\} \cdot \left\{ E(R_i) - R_f \right\} \qquad (1)$$

Note that $\{[S/C] \cdot [\partial C/\partial S]\}$ contains two interesting elements. The first is simply the ratio of the stock price to option price. The second represents the inverse of the hedge ratio. Recall in the Black-Scholes formulation that the hedge ratio can be represented as

$$(\frac{\partial C}{\partial S})^{-1} = N(d_1)^{-1}$$

Therefore, $\frac{\partial C}{\partial S} = N(d_1)$.

Furthermore, Black and Scholes [1973; pp. 645-646] suggest the entire expression $\{[S/C] \cdot [\partial C/\partial S]\}$ can be interpreted as the "elasticity" of the option price with respect to the stock price; that is, the ratio of the percentage change in the option price to the percentage change in the stock price, for small percentage changes, holding maturity constant.

Now, recall from the familiar capital asset pricing model (CAPM), the relation:

$$E(R_i) - R_f = \beta_i [E(R_m) - R_f] \qquad (2)$$

If we assume the short-term interest rate (R_f) is the same in both models, and substitute the right hand side (RHS) of equation (2) into equation (1), we get:

$$E(R_C) - R_f = \left\{ [\frac{S}{C}] N(d_1) \right\} \left\{ \beta_i [E(R_m) - R_f] \right. \qquad (3)$$

We recognize the now familiar relationship, noting the beta of the option (β_C) can be rewritten as:

$$\beta_C = \left\{ [\frac{S}{C}] N(d_1) \right\} \beta_i \qquad (4)$$

Contrast this with Lee, Rao, and Auchmuty's [1981] equation (7), page 11:

$$\beta_C = \left\{ [\frac{S}{C}] N(d_1^*) \right\} (1+\Phi)\beta_i \qquad (5)$$

It can readily observed (through the d_1^* and Φ components) that their significantly more complex relation allows for the expected logarithmic return on the underlying stock (μ_i) as well as the logarithmic covariance (σ_{im}) to be impounded in the option price. The effect of this extension is that (rather than forcing a RNVR to obtain) LRA's β_C allows the systematic risk of the call option to be priced, thereby incorporating these market effects.

Furthermore, LRA point out that when $\sigma_{im} = 0$, in which case from the lognormal CAPM, $\mu_i = R_f$** so that $d_1^* = d_1$, $d_2^* = d_4^*$, and $d_3^* = d_1^*$ making both $\Phi = 0$ and $\theta = 0$, the new call option valuation degenerates to the Black-Scholes call option price.

** That is, $E(R_{iT}) = R_f$(i.e., a RNVR obtains).

APPENDIX C

The purpose of this appendix is to incorporate the dividend adjustment suggested by Merton [1973] and the capital structure adjustment suggested by Smith [1979] into the equilibrium option pricing model (for a lognormal securities market) derived by Lee, Rao, and Auchmuty [1981]. This adaptation will make use of the solution to the differential equation put forth by LRA in Lemmas 1 and 2. The new call option value will be derived through an arbitrage argument (i.e., a hedging strategy) similar to that employed by Black and Scholes [1973; pp. 642-646] outlined by LRA [pp. 85-87].

Before proceeding to the formal proof, it is useful to make the following observation about the relationship which holds between the beta of the option (β_C), the ratio of stock price (S) to option price (C), the inverse of the hedge ratio ($\partial C/\partial S$),* and the beta of the underlying stock (β_i) in every single option pricing relationship specified:

$$\beta_C = \left\{ [\frac{S}{C}] [\frac{\partial C}{\partial S}] \right\} \beta_i$$

Because of different models for the call option price (C), the relationship between β_c and β_i is affected.

It will be insightful to review the four relationships between β_C and β_i specified in this study.

In Black-Scholes:

$$\beta_C = \left\{ [\frac{S}{C}] \; [\frac{\partial C}{\partial S}] \right\} \beta_i \qquad \text{where}$$

$$\frac{\partial C}{\partial S} = N(d_1)$$

As adjusted by Merton for dividends:
(Note: y is defined as the constant, known, continuous dividend yield on the underlying common stock.)

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* The hedge ratio (H.R.) is defined as the inverse of the change in option price relative to the change in stock price:

$$H.R. = (\frac{\partial C}{\partial S})^{-1}$$

Therefore, the inverse of the H.R. can be written as:

$$[(\frac{\partial C}{\partial S})^{-1}]^{-1} = \frac{\partial C}{\partial S}$$

Recall, the H.R. relationship stipulates the number of options that must be sold short against one share of stock held so as to maintain a risk-free portfolio.

$$\beta_C = \left\{ [\frac{S}{C}] \ [\frac{\partial C}{\partial S}] \right\} \beta_i \qquad \text{where}$$

$$\frac{\partial C}{\partial S} = e^{-YT} N(d_1)$$

In Lee, Rao, and Auchmuty [p. 84; equation (7)]:

$$\beta_C = \left\{ [\frac{S}{C}] \ [\frac{\partial C}{\partial S}] \right\} \beta_i \qquad \text{where}$$

$$\frac{\partial C}{\partial S} = N(d_1^*) [1+\Phi]$$

And correspondingly, adjusting the LRA model for dividends:*

$$\beta_C = \left\{ [\frac{S}{C}] \ [\frac{\partial C}{\partial S}] \right\} \beta_i \qquad \text{where}$$

$$\frac{\partial C}{\partial S} = e^{-YT} N(d_1^*) [1+\Phi]$$

Now, the arbitrage proof outlined in LRA may be employed.

First, form a portfolio consisting of two assets, the call option and the underlying stock. Define Ω as the proportion of the portfolio value invested in the call option and $(1-\Omega)$ as the investment in the stock.

The beta of the portfolio, β_p, may be represented by a linear combination of the β's of the two assets:

$$\beta_p = \Omega \left\{ [\frac{S_i}{C_i}] [e^{-YT} N(d_1^*)(1+\Phi)] \beta_i + (1-\Omega)\beta_i \right.$$

Now choose Ω such that the portfolio has zero systematic risk (i.e., select $\Omega = \Omega^*$ so as to make $\beta_p = 0$).

$$-\Omega \left\{ [\frac{S_i}{C_i}] [e^{-YT} N(d_1^*)(1+\Phi)] \beta_i = (1-\Omega)\beta_i \right.$$

Multiply both sides of equation by $\frac{1}{\beta_i}$.

$$-\Omega \left\{ [\frac{S_i}{C_i}] [e^{-YT} N(d_1^*)(1+\Phi)] \right\} = (1-\Omega)$$

---

* See Appendix D

Divide both sides by $-\Omega$.

$$[\frac{S_i}{C_i}][e^{-yT}N(d_1^*)(1+\Phi)] = \frac{-(1-\Omega)}{\Omega}$$

Simplify right hand side (RHS).

$$[\frac{S_i}{C_i}][e^{-yT}N(d_1^*)(1+\Phi)] = -\Omega^{-1} + 1$$

Subtract 1 from both sides and multiply through by -1.

$$-\{[\frac{S_i}{C_i}][e^{-yT}N(d_1^*)(1+\Phi)]\} + 1 = \Omega^{-1}$$

Rearrange LHS and take reciprocal of both sides.

$$\left([1 - \{[\frac{S_i}{C_i}][e^{-yT}N(d_1^*)(1+\Phi)]\}]\right)^{-1} = \Omega = \Omega^* \qquad (1)$$

Note: this equation is analogous to LRA equation (10) [p. 86].

Now, since the portfolio has <u>zero</u> systematic risk (i.e., $\beta_p = 0$) [see Ross [1976]], the expected return on the portfolio over time T, must be equal to the risk free rate of interest (R_f). That is:

$$E(R_{pT}) = \Omega^* E(R_{cT}) + (1-\Omega^*)E(R_{iT}) = R_f \qquad (2)$$

Note: to simplify burdensome notation, a second subscript "T" will be added only when specifying expectation parameters (where T indicates time <u>to</u> expiration of the option). Therefore, S_i and C_i denote <u>current</u> stock and option price, respectively; and the subscripts p, c, and i denote the portfolio, the option, and the stock, respectively. Finally, by definition:

$E(S_{iT}) \equiv$ expected stock price (adjusted here for dividends) at time T (the expiration date in the future), where

$$E(S_{iT}) \equiv S_i e^{-yT} E(R_{iT}).$$

Observe that the continuous dividend yield (y) affects the expected future stock price. Recall LRA equation (6) [p. 84] for the expected return on the option:

$$E(R_{cT}) = \frac{E(S_{iT})N(d_1^*)}{C_i} - \frac{XN(d_2^*)}{C_i}$$

Note here, because of the dividend adjustment, the expected return would be specified as:

$$E(R_{cT}) = \frac{S_i e^{-yT} E(R_{iT}) N(d_1^*)}{C_i} - \frac{XN(d_2^*)}{C_i} \tag{3}$$

Substituting our equations for Ω^* and $E(R_{CT})$ into the equation for the expected return on the portfolio (i.e., equations (1) and (3) into (2)), generates

$$E(R_{pT}) = \left(1-\left\{\left[\frac{S_i}{C_i}\right]\left[e^{-yT} N(d_1^*)(1+\Phi)\right\}\right)^{-1} \cdot \left(\frac{S_i e^{-yT} E(R_{iT}) N(d_1^*) - XN(d_2^*)}{C_i}\right)$$

$$+ 1-\left(1-\left\{\left[\frac{S_i}{C_i}\right]\left[e^{-yT} N(d_1^*)(1+\phi)\right]\right\}\right)^{-1} \cdot \left(E(R_{iT})\right) = R_f \tag{4}$$

Simplifying yields the following:

$$E(R_{pT}) = \left(\frac{C_i}{C_i - S_i e^{-yT} N(d_1^*)(1+\Phi)}\right) \cdot \left(\frac{S_i e^{-yT} E(R_{iT}) N(d_1^*) - XN(d_2^*)}{C_i}\right)$$

$$+ \left(\frac{C_i - S_i e^{-yT} N(d_1^*)(1+\Phi) - C_i}{C_i - S_i e^{-yT} N(d_1^*)(1+\Phi)}\right) \cdot \left(E(R_{iT})\right) = R_f \tag{5}$$

Rewriting over a common denominator:

$$E(R_{pT}) = \frac{S_i e^{-yT} E(R_{iT}) N(d_1^*) - XN(d_2^*) - S_i e^{-yT} N(d_1^*)(1+\Phi) E(R_{iT})}{C_i - S_i e^{-yT} N(d_1^*)(1+\Phi)}$$

$$= R_f \tag{6}$$

Cross-multiply:

$$E(R_{pT}) = C_i - S_i e^{-yT} N(d_1^*)(1+\Phi)$$

$$= \frac{S_i e^{-yT} E(R_{iT}) N(d_1^*) - XN(d_2^*) - S_i e^{-yT} N(d_1^*)(1+\Phi) E(R_{iT})}{R_f} \tag{7}$$

Rewrite and breakdown into three components:

$$E(R_{pT}) = C_i = \{\frac{S_i e^{-yT} N(d_1^*)(1+\Phi) R_f}{R_f}\}$$

$$+ \{\frac{S_i e^{-yT} E(R_{iT}) N(d_1^*) - S_i e^{-yT} N(d_1^*)(1+\Phi) E(R_{iT})}{R_f}\}$$

$$- \{\frac{XN(d_2^*)}{R_f}\} \qquad (8)$$

Factor the second component:

$$E(R_{pT}) = C_i = \{\frac{S_i e^{-yT} N(d_1^*)(1+\Phi) R_f}{R_f}\}$$

$$+ \{\frac{S_i e^{-yT} E(R_{iT}) N(d_1^*)[1-(1+\Phi)]}{R_f}\} - \{\frac{XN(d_2^*)}{R_f}\} \qquad (9)$$

Factor the first and second component:

$$E(R_{pT}) = S_i e^{-yT} N(d_1^*) \frac{\{[(1+\Phi)R_f] + [E(R_{iT})(1-(1+\Phi))]\}}{R_f} - \{\frac{XN(d_2^*)}{R_f}\}$$

$$= C_i \qquad (10)$$

Expand and simplify:

$$E(R_{pT}) = X_i e^{-yT} N(d_1^*) \frac{\{R_f + \Phi R_f + E(R_{iT})(-\Phi)\}}{R_f} - \{\frac{XN(d_2^*)}{R_f}\} = C_i \qquad (11)$$

Simplify:

$$E(R_{pT}) = S_i e^{-yT} N(d_1^*) \frac{(1 + \{\Phi[R_f + E(R_{iT})]\})}{R_f} - \{\frac{XN(d_2^*)}{R_f}\} = C_i \qquad (12)$$

To simplify,

$$\text{Let } -\theta = \{\frac{\Phi[R_f - E(R_{iT})]}{R_f}\}$$

Then,

$$\theta = \frac{\Phi[E(R_{iT}) - R_f]}{R_f}$$

By definition (from LRA Lemma 1):

$E(R_{iT}) \equiv \exp\ (\mu_{iT})$ and

$R_f \equiv \exp\ (r_{fT})$

Therefore, substituting:

$$\theta = \{\frac{\exp(\mu_{iT}) - \exp(r_{fT})}{\exp(r_f T)}\}\Phi$$

Substitute back into equation (12):

$$E(R_{pT}) = S_i e^{-yT} N(d_1^*)[1-\theta[- \{\frac{XN(d_2^*)}{R_f}\} = C_i \tag{13}$$

Rewrite:

$$E(R_{pT}) = S_i e^{-yT} N(d_1^*)[1-\theta] - \{[XN(d_2^*)][R_f]^{-1}\} = C_i \tag{14}$$

Note: If $R_f \equiv \exp(r_f T)$, then

$[R_f]^{-1} = \exp(-r_f T)$, and of course

$e^{-yT} = \exp(-yT)$

Inserting notation generates the finished product:

$$E(R_{pT}) = C_i = S_i \exp(-yT)[1-\theta]N(d_1^*) - X\exp(-r_f T)N(d_2^*) \tag{15}$$

where $\theta = \{\dfrac{\exp(\mu_{iT}) - \exp(r_f T)}{\exp(r_f T)}\}\ \Phi$

and $\Phi = \dfrac{[N(d_3^*)-N(d_1^*)]\exp(\sigma_{im}T) + N(d_2^*)-N(d_4^*)}{N(d_1^*)[\exp(\sigma_{im}T) - 1]}$

Finally, observe the distributional parameters* that rather than forcing a RNVR to obtain (like Black and Scholes), market effects are allowed to surface in the model through the expected logarithmic return on the underlying asset (μ_i), and its logarithmic covariance with the market return (σ_{im}). The only difference between these parameters and those specified by LRA is that the expected return must be reduced by the continuous dividend yield (μ_i-y). Thus, the four parameters become:

$$d_1^* = (\sigma_i\sqrt{T})^{-1}\{\ln[\frac{S_i}{X}] + [(\mu_i-y)+ \frac{1}{2}\sigma_i^2]T\}$$

$$d_2^* = d_1^* - \sigma_i\sqrt{T}$$

$$d_3^* = (\sigma_i\sqrt{T})^{-1}\{\ln[\frac{S_i}{X}] + [(\mu_i-y) + \frac{1}{2}\sigma_1^2 + \sigma_{im}]T\}$$

$$d_4^* = d_3^* - \sigma_i\sqrt{T} \qquad \text{Q.E.D.}$$

Smith [1979] has suggested a second adjustment to the OPM which is necessary to accomodate the potential capital structure effect (i.e., dilution) the exercise of warrants causes. This adjustment does not upset the status of the OPM as an equilibrium relationship; it merely prescribes that relationship for the entire warrant issue instead of for a single warrant.

To implement this adjustment it is only necessary to redefine three variables and substitute this α adjustment into LRA's OPM as follows:

Let W ≡ The price (value) of the entire warrant issue. It is the product of w (≡ the warrant price for a single share of stock) and Q_W (≡ the number of shares that would be sold through the total warrant issue).
That is, $W = w \cdot Q_W$.

V ≡ The total value of the firm's assets. It is the product of S(≡ the stock price of a single share) and Q_S (≡ the number of shares of common stock currently outstanding in the market prior to exercise).
That is, $V = s \cdot Q_S$.

---

* Note: $1-d_1^* = N(d_1^*)$, $1-d_2^* = N(d_2^*)$, etc.
That is, $N(d_1^*)$, $N(d_2^*)$, etc. are the probabilities that a random variable with a standardized normal distribution will take on values less than d_1, d_2, etc.

X^N ≡ The total proceeds to the firm if all the warrants are exercised. It is the product of X (≡ the exercise price of the warrant per share of common stock) and Q_w (as previously defined).
That is $X^N = X \cdot Q_w$.

α ≡ The potential dilution effect if all the warrants are exercised. It is defined as: $Q_w/(Q_w + Q_s)$.

Finally to obtain the WPM #2 used in this study, simply make the following substitutions: W_i for C_i, αV_i for S_i, and $(1-\alpha)X^N$ for X. This generates the following model:

$$W_i = \exp(-yT)\alpha V_i[1-\theta]N(d_1^*) - (1-\alpha)X^N\exp(-r_fT)N(d_2^*)$$

$$\text{where } \theta = \frac{\exp(\mu_iT) - \exp(r_fT)}{\exp(r_fT}\Phi$$

$$\text{and} \quad \Phi = \frac{[N(d_3^*) - N(d_1^*)]\exp(\sigma_{im}T) + N(d_2^*) - N(d_4^*)}{N(d_1^*)[\exp(\sigma_{im}T) - 1]}$$

$$\text{with} \quad d_1^* = (\sigma_i\sqrt{T})^{-1}\left[\ln\left(\frac{\alpha V_i}{(1-\alpha)X^N}\right) + (\mu_i - y + \frac{1}{2}\sigma_i^2)T\right]$$

$$d_2^* = d_1^* - \sigma_i\sqrt{T}$$

$$d_3^* = (\sigma_i\sqrt{T})^{-1}\left[\ln\left(\frac{\alpha V_i}{(1-\alpha)X^N}\right) + (\mu_i - y + \frac{1}{2}\sigma_i^2 + \sigma_{im})T\right]$$

$$d_4^* = d_3^* - \sigma_i\sqrt{T}$$

APPENDIX D

To derive the new hedge ratio (H.R.) for the LRA option pricing model adjusted for a constant, known, continuous dividend yield on the underlying common stock (y). Recall [from Appendix C] that Ω^* was defined as the porportion of the riskless (i.e., hedged) portfolio invested in the call option and $(1 - \Omega^*)$ represented the remaining investment in the stock. It now follows that for a $1 investment (in the entire portfolio), that $\Omega^* = Q_c C_i$ and $(1-\Omega^*) = Q_s S_i$ where Q_c and Q_s denote the number of call options and shares of stock, respectively. The hedge ratio (i.e., $[\partial C/\partial S]^{-1}$) therefore, can be represented by the ratio of quantities as follows:

$$\frac{Q_c}{Q_s} = \left[\frac{\Omega^*}{1 - \Omega^*}\right]\left[\frac{S_i}{C_i}\right]$$

Substitute equation (1) from Appendix C in for Ω^*'s:

$$\frac{Q_c}{Q_s} = \frac{\left(1 - \left\{\left[\frac{S_i}{C_i}\right]\left[e^{-yT}N(d_1^*)(1+\Phi)\right]\right\}\right)^{-1}}{1 - \left(1 - \left\{\left[\frac{S_i}{C_i}\right]\left[e^{-yT}N(d_1^*)(1+\Phi)\right]\right\}\right)^{1}} \cdot \left[\frac{S_i}{C_i}\right]$$

Rewrite:

$$\frac{Q_c}{Q_s} = \frac{\left(C_i - S_i e^{-yT}N(d_1^*)(1+\Phi)\right)^{-1} C_i}{1 - \left(C_i - S_i e^{-yT}N(d_1^*)(1+\Phi)\right)^{-1} C_i} \cdot \left[\frac{S_i}{C_i}\right]$$

Cancel C_i's and rewrite:

$$\frac{Q_c}{Q_s} = \frac{S_i}{\left(C_i - S_i e^{-yT}N(d_1^*)(1+\Phi)\right) \cdot \left\{1 - \left(C_i - S_i e^{-yT}N(d_1^*)(1+\Phi)\right)^{-1} C_i\right\}}$$

Now, for computational expediency,

Let $S_i e^{-yT}N(d_1^*)(1+\Phi) = \Delta$

Rewrite:

$$\frac{Q_c}{Q_s} = \frac{S_i}{\left(C_i - \Delta\right) \cdot \left\{1 - \left(C_i - \Delta\right)^{-1} C_i\right\}}$$

Expand denominator:

$$\frac{Q_c}{Q_s} = \frac{S_i}{(C_i-\Delta)\left(1 - \frac{C_i}{[C_i-\Delta]}\right)}$$

Rewrite:

$$\frac{Q_c}{Q_s} = \frac{S_i}{(C_i-\Delta)\left(\frac{C_i-\Delta-C_i}{C_i-\Delta}\right)}$$

Rewrite:

$$\frac{Q_c}{Q_s} = \frac{S_i}{C_i-\Delta- C_i}$$

Rewrite:

$$\frac{Q_c}{Q_s} = \frac{S_i}{-\Delta}$$

Substitute expression for Δ back in:

$$\frac{Q_c}{Q_s} = \frac{S_i}{-S_i e^{-yT} N(d_1^*)(1+\Phi)}$$

Cancel S_i's:

$$\frac{Q_c}{Q_s} = \frac{-1}{e^{-yT} N(d_1^*)(1+\Phi)}$$

Rewrite:

$$\frac{Q_c}{Q_s} = \frac{-e^{yT}}{N(d_1^*)(1+\Phi)}$$

Q.E.D.

Note: The negative sign merely indicates the number of options to be sold <u>short</u> against a long stock position.

This hedge ratio written as the ratio of their quantities represents $[\partial C/\partial S]^{-1}$. Substituting Smith's [1979] parameters (see Appendix C) for C and S generates $[\partial W/\partial \alpha V]^{-1}$. Recall that this warrant characterization of the OPM is for the entire warrant issue, not a single call option. To see this capital structure adjustment has no effect on the hedge ratio, it is useful to decompose this ratio into its variable and fixed components. By assumption, the quantity of warrants (Q_W), the quantity of stock (Q_S), and the α ratio are fixed per firm per time period studied. Rewriting this hedge ratio as $[\bar{Q}_W/(\bar{\alpha} \cdot \bar{Q}_S) \cdot (\partial W/\partial S)]^{-1}$ and then dropping the constants provides the more familiar form $[\partial W/\partial S]^{-1}$. Thus it is clear that the hedge ratio is not directly affected by the potential dilution to equity interests caused by exercise.

APPENDIX E

This appendix contains a list of every firm used in this study. The firm numbers correspond to the numbers used in Tables One through Four.

FIRM NUMBER	FIRM NAME	EXERCISE DATE	EXERCISE PRICE	CONVERSION RATIO
1	Amax Inc.	10- 1-77	$47.50	1:1
2	Amerada Hess Corp.	6-15-76	40.50	1:1
3	Atlantic Richfield	12-31-76	127.50	1:1
4	Bangor Punta Corp.	3-31-81	51.89	1:1.059
5	Bell Telephone CDA	6-30-77	46.00	1:1
6	Brown Co.	5-15-80	13.20	1:1.25
7	Carrier Corp.	7-15-76	27.33	1:1
8	Continental Tel. Corp.	11- 5-79	21.55	1:1.038
9	Delta Air Lines	5- 1-78	48.00	1:1
10	E-Systems Inc.	8-15-78	23.32	1:.915
11	First Union Real Est.	12- 1-77	12.75	1:1
12	Fuqua Inds. Inc.	10-31-78	21.40	1:1
13	Govt. Employees Ins.	8- 1-78	31.22	1:2.08
14	Gulf & Western Inds.	1-31-78	19.37	1:1.42
15	Hospital Mtg. Group	2-16-77	25.00	1:1
16	Itel Corp.	5- 1-78	6.25	1:1
17	Itel Corp.	1-15-79	26.00	1:1.15
18	Kane Miller Corp.	1-15-80	12.93	1:1.875
19	Koger Prop. Inc.	6-30-77	4.33	1:1.5
20	Koger Prop. Inc.	7- 1-79	17.00	1:1
21	Loews Corp.	11-29-80	40.00	1:1
22	McCrory Corp.	3-15-81	45.00	1:.5
23	Molycorp Inc.	4- 7-77	15.00	1:1
24	Northwest Inds.	3-31-79	12.50	1:2
25	Occidental Pete.	4-22-80	16.25	1:1
26	PNB Mtg. & Rlty. Inv.	12-31-77	20.00	1:1
27	Realty Refund Tr.	6-14-77	20.00	1:1
28	Realty Refund Tr.	9- 1-78	23.00	1:1
29	Realiance Group	6- 4-78	32.07	1:1
30	Republic Air - North	10-31-79	5.50	1:1
31	Republic Air - South	7- 1-81	2.86	1:2.1
32	San Francisco Rl. Est.	12-31-80	25.00	1:1
33	Tejas Gas Corp.	12-31-76	9.50	1:1
34	Tenneco Inc.	4- 1-79	30.07	1:1.07
35	Tesoro Pete. Corp.	8-24-76	13.80	1:1
36	Total Pete. NA Ltd.	12-31-80	10.00	1:1
37	U.V. Indus. Inc.	1-15-79	20.66	1:1.065
38	United Brands	2- 1-79	46.00	1:1
39	United Realty Tr.	12-27-79	20.00	1:1
40	United Telecomm.	4-14-77	16.93	1:1.03
41	Whittaker Corp.	5- 5-79	50.00	1:1
42	Wyoming Natl. Corp.	9-15-77	20.00	1:1
43	Zondervan Corp.	9- 9-81	6.17	1:1.5

APPENDIX F

The purpose of this appendix is to demonstrate that one variable used in the statistical analysis, the mean/variance, provides the same t-statistic value as a Generalized Least Squares (GLS) estimate of the underlying population parameter.

Assume that the errors of ΔISD's around ΔSD are independently distributed cross-sectionally, as well as identically and independently distributed intertemporally. These assumptions are consistent with the characterization of the process being modeled. [see section 4.1]

Consider the statistic:

$$M = \frac{1}{J} \sum_{j=1}^{J} \frac{\overline{\Delta ISD}_j}{VAR(\overline{\Delta ISD}_j)} \tag{1}$$

Recall that the VAR $(k\tilde{x}) = k^2 Var(\tilde{x})$, where k is a constant and $\tilde{x}$ is a random variable. Because the ΔISD_j's are assumed to be independent, the variance of the sum is:

$$\frac{1}{J^2} \sum_{j=1}^{J} \frac{VAR(\overline{\Delta ISD}_j)}{VAR(\overline{\Delta ISD}_j)^2} = \frac{1}{J^2} \sum_{j=1}^{J} \frac{1}{VAR(\overline{\Delta ISD}_j)}$$

$$= \frac{1}{J^2} \sum_{j=1}^{J} \left[\frac{1}{\frac{VAR(\Delta ISD_j)}{T}} \right] = \frac{1}{J^2} \sum_{j=1}^{J} \frac{T}{VAR(\Delta ISD_j)}$$

where T corresponds to the number of time-series observations included in the average.

The variance of the average may be written as:

$$\frac{1}{J^2} \sum_{j=1}^{J} \frac{T}{VAR(\Delta ISD_j)}$$

Therefore, the t-ratio for this variable may be written as:

$$t = \frac{\frac{1}{J} \sum_{j=1}^{J} T \frac{\overline{\Delta ISD}_j}{VAR(\Delta ISD_j)}}{\sqrt{\frac{1}{J^2} \sum_{j=1}^{J} \frac{T}{VAR(\Delta ISD_j)}}}$$

$$= \frac{\frac{1}{J} T \sum_{j=1}^{J} \frac{\overline{\Delta ISD}_j}{VAR(\Delta ISD_j)}}{\frac{1}{J} \sqrt{T} \sqrt{\sum_{j=1}^{J} \frac{1}{VAR(\Delta ISD_j)}}}$$

$$= \frac{\sqrt{T} \sum_{j=1}^{J} \frac{\overline{\Delta ISD}_j}{VAR(\Delta ISD_j)}}{\sqrt{\sum_{j=1}^{J} \frac{1}{VAR(\Delta ISD_j)}}} \tag{2}$$

The firm variances are estimated for each of the regimes using the twenty-two observations prior to the dividend announcement. The numerator of the t's will be approximately normally distributed because each of the individual elements is approximately normally distributed. The t-statistic itself has 39 degrees of freedom reflecting the 40 firms cross-sectionally averaged. This is the t-statistic value of the variable used in this study.

Now, to see that this provides the same t-value as that generated by a joint GLS estimate, consider joint GLS on the pooled system of equations specified in section 4.1, subject to the constraint that $\Delta SD_j = \Delta SD$ for all j firms (j=1,J).

Theil, [1971; p. 308] provides the following GLS regression coefficient vector of ΔSD_j:

$$\hat{\Gamma} = (X'S^{-1}X)^{-1} X^{1} S^{-1} R \tag{3}$$

The covariance matrix of this estimator is given as:

$$(X' S^{-1}X)^{-1}$$

where:

$$X \equiv \frac{1}{J} \otimes \frac{1}{T}$$

$$S \equiv \Omega \otimes I$$

$\Omega \equiv$ a consistent estimate of the J x J contemporaneous covariance matrix of ε_j's for each firm j. In this case, the sample covariance matrix of the ΔISD_j's around their respective means ($\overline{\Delta ISD}_j$'s).

$I \equiv$ a $T \otimes T$ Identity matrix.

$$R \equiv \begin{bmatrix} \Delta ISD_{j1} \\ \Delta ISD_{j2} \\ \cdot \\ \cdot \\ \cdot \\ \Delta ISD_{j29} \\ \cdot \\ \cdot \\ \cdot \\ \Delta ISD_{j+1\,t} \\ \cdot \\ \cdot \\ \cdot \\ \Delta ISD_{JT} \end{bmatrix}$$

R is a stacked vector of all ISD differences $[(J \times T) \times 1]$, where $j = 1, J$ and $t = 1, T$.

Rewrite (3) in Kronecker notation:

$$\hat{\Gamma} = \left[\underset{J}{1'} \otimes \underset{T}{1'} \left(\underset{JxJ}{\Omega^{-1}} \otimes \underset{TxT}{I} \right) \underset{J}{1} \otimes \underset{T}{1}\right]^{-1} \underset{J}{1'} \otimes \underset{T}{1'} \left(\underset{JxJ}{\Omega^{-1}} \otimes \underset{TxT}{I} \right) \underset{[(JxT)X1]}{R}$$

Using the principle of Kronecker products (see Theil [1971; pp. 303-306]) that $(A \otimes B)(C \otimes D) = AC \otimes BD$, rewrite:

$$\hat{\Gamma} = \{[(1' \;\; \Omega^{-1}) \otimes (1' \; I)] \; [1 \otimes 1]\}^{-1} \; [(1' \; \Omega^{-1}) \otimes (1' \; I)]R$$

$$= \{(1' \; \textstyle\sum^{-1} \; 1) \otimes (1' \; I \; 1)\}^{-1} \; [(1' \; \textstyle\sum^{-1}) \otimes (1' \; I)]R$$

Rewrite:

$$= [(1' \; \Omega^{-1} \; 1) \otimes (1' \cdot 1)]^{-1} \; [(1 \; \Omega^{-1} \otimes 1')]R$$

Using the principle of Kronecker products that $(A \otimes B)^{-1} = A^{-1} \otimes B^{-1}$, rewrite:

$$\hat{\Gamma} = [(1' \; \Omega^{-1} \; 1)^{-1} \otimes (1' \; 1)^{-1}] \; (1 \; \Omega^{-1} \otimes 1') \; R$$

Simplify:

$$\hat{\Gamma} = [(1' \; \Omega^{-1} \; 1)^{-1} \cdot 1] \; (1 \; \Omega^{-1} \otimes 1') \; R$$

Let Ω be diagonal (i.e., the off diagonal elements of the $J \times J$ matrix are equal to zero). Then by definition,

$$1' \, \Omega^{-1} \, 1 = \sum_{j=1}^{J} \frac{1}{VAR(\Delta ISD_j)}$$

And the variance of this estimator is:

$$\frac{1}{T} \cdot \frac{1}{\sum_{j=1}^{J} \frac{1}{VAR(\Delta ISD_j)}}$$

Substitute:

$$\hat{\Gamma} = \left[\frac{1}{T} \cdot \frac{1}{\sum_{j=1}^{J} \frac{1}{VAR(\Delta ISD_j)}} \right] \left[\frac{1}{\sum_{j=1}^{J} \frac{1}{VAR(\Delta ISD_j)}} \cdot 1 \right] R$$

Recall, $R = \sum_{J=1}^{J} \sum_{t=1}^{T} \Delta ISD_{jt}$

Simplifying,

$$R = T \sum_{j=1}^{J} \Delta \overline{ISD}_j$$

Substitute:

$$\hat{\Gamma} = \left[\frac{1}{T} \cdot \frac{1}{\sum_{j=1}^{J} \frac{1}{VAR(\Delta ISD_j)}} \right] \left[\frac{1}{\sum_{j=1}^{J} VAR(\Delta ISD_j)} \cdot T \sum_{j=1}^{J} \Delta \overline{ISD}_j \right]$$

Simplify (note, the T's cancel out):

$$\hat{\Gamma} = \left[\frac{1}{\sum_{j=1}^{J} \frac{1}{VAR(\Delta ISD_j)}} \right] \left[\sum_{j=1}^{J} \frac{\Delta \overline{ISD}_j}{VAR(\Delta ISD_j)} \right]$$

Thus the GLS estimator ($\hat{\Gamma}$) can be written as:

$$\hat{\Gamma} = \frac{\sum_{j=1}^{J} \frac{\Delta \overline{ISD}_j}{VAR(\Delta ISD_j)}}{\sum_{j=1}^{J} \frac{1}{VAR(\Delta ISD_j)}}$$

When the variances are replaced by the same estimates used in equation (2), the joint GLS estimate of $\hat{\Gamma}$ is:

$$\hat{\Gamma} = \frac{\sum_{j=1}^{J} \frac{\Delta\overline{ISD}_j}{\hat{VAR}(\Delta ISD_j)}}{\sum_{j=1}^{J} \frac{1}{\hat{VAR}(\Delta ISD_j)}}$$

$$\text{where } \hat{VAR} = \frac{\sum_{t=1}^{T} (\Delta ISD_{jt} - \Delta\overline{ISD}_j)^2}{T - 1}$$

The t-statistic for this estimator is given by:

$$t = \frac{\sum_{j=1}^{J} \frac{\Delta\overline{ISD}_j}{\hat{VAR}(\Delta ISD_j)}}{\sum_{j=1}^{J} \frac{1}{\hat{VAR}(\Delta ISD_j)}} \cdot \frac{1}{\sqrt{\frac{1}{T} \frac{1}{\sum_{j=1}^{J} \frac{1}{\hat{VAR}(\Delta ISD_j)}}}}$$

Simplify,

$$t = \frac{\sum_{j=1}^{J} \frac{\Delta\overline{ISD}_j}{\hat{VAR}(\Delta ISD_j)}}{\sum_{j=1}^{J} \frac{1}{\hat{VAR}(\Delta ISD_j)}} \cdot \frac{1}{\frac{1}{\sqrt{T}} \sqrt{\frac{1}{\sum_{j=1}^{J} \frac{1}{\hat{VAR}(\Delta ISD_j)}}}}$$

$$= \frac{\sum_{j=1}^{J} \frac{\Delta\overline{ISD}_j}{\hat{VAR}(\Delta ISD_j)}}{\sum_{j=1}^{J} \frac{1}{\hat{VAR}(\Delta ISD_j)}} \cdot \frac{\sqrt{T}}{\sqrt{\frac{1}{\sum_{j=1}^{J} \frac{1}{\hat{VAR}(\Delta ISD_j)}}}}$$

$$= \frac{\dfrac{\sum\limits_{j=1}^{J} \dfrac{\Delta\overline{ISD}_j}{V\hat{A}R(\Delta ISD_j)}}{\sum\limits_{j=1}^{J} \dfrac{1}{V\hat{A}R(\Delta ISD_j)}}}{\sqrt{\sum\limits_{j=1}^{J} \dfrac{1}{V\hat{A}R(\Delta ISD_j)}}} \cdot \sqrt{T}$$

Finally:

$$t = \frac{\sqrt{T} \sum\limits_{j=1}^{J} \dfrac{\Delta\overline{ISD}_j}{V\hat{A}R(\Delta ISD_j)}}{\sqrt{\sum\limits_{j=1}^{T} \dfrac{1}{V\hat{A}R(\Delta ISD_j)}}}$$

This is the same t-value as the t-statistic in equation (2).

GLOSSARY

American-type option ≡ a marketable security with identical terms and features to its European counterpart, except that it may be exercised on <u>or</u> before its expiration date.

bear ≡ market price of security is going down.

bull ≡ market price of security is going up.

call option ≡ the right to purchase (buy) a share of stock.

call price ≡ the value of the option (i.e., market price).

contingent claim ≡ a (derivative) asset whose payoff depends upon the value of another "underlying" asset, the value of which is exogenously determined.

down-and-outer ≡ an option containing the same terms with respect to exercise price, antidilution clauses, etc., as the standard (American) call option, but with one unique feature: if the stock price falls below a stated level (known as the knock-out price), the option contract is nullified (i.e., it becomes worthless).

European-type option ≡ a marketable security with the same terms as a warrant, except it is issued by a private individual in the market, not the firm itself, and it can only be exercised on a specified date (i.e., the last day of the option contract).

exercise price ≡ the dollar amount that must be remitted to the issuer upon exercise of the option in return for a share of stock.

expiration date ≡ the date on which the option must be exercised (European) or the date on or before which the option may be exercised (American), otherwise it expires worthless.

in-the-money option ≡ an option for which the stock price exceeds the exercise price by a "large" amount. (Also known as deep - or well-in-the-money).

knock-out price ≡ the stock price below which a "downand-outer" becomes worthless.

option ≡ a generic expression, loosely used in reference to any of several types of marketable securities containing an exercise provision and offering high leverage and limited liability to the buyer. (See call option, put option, warrant.)

option premium ≡ the option writer's (i.e., the issuer's) compensation.

out-of-the-money option ≡ an option for which the exercise price exceeds the stock price by a "large" amount. (Also known as deep- or well-out-of-the-money.)

put option ≡ the right to sell a share of stock.

spread ≡ a more complex hedging strategy which involves buying a call and writing a call (or buying a put) on the same stock, where each side of the option has a different exercise price.

stock right ≡ a right (issued by the firm) to purchase a specified number of shares (or a proportion of a share), issued to current stockholders (to prevent anti-dilution) that can be exercised or sold to another party.

straddle ≡ a hedging strategy made up of 1 put option and 1 call option.

strap ≡ a hedging strategy made up of 1 put option and 2 call options.

strip ≡ a hedging strategy made up of 2 put options and 1 call option.

warrant ≡ a marketable security, offering high leverage and limited liability (to the buyer), which is issued by a company (i.e., the firm itself), giving its owner the right to purchase a share of stock at a given (exercise) price on (or before) a specified date. [A firm's counterpart to a private individual's option.]

BIBLIOGRAPHY

Aharony, Joseph and Itzhak Swary, "Quarterly Dividend and Earnings Announcements and Stockholders' Returns: An Empirical Analysis," The Journal of Finance (March 1980), pp. 1-12.

Arrow, Kenneth J., Essays in the Theory of Risk-Bearing, (Amsterdam: North Holland, 1971).

Ball, Ray, "Anomalies in Relationships Between Securities' Yields and Yield Surrogates," Journal of Financial Economics (June-September 1978), pp. 103-126.

Ball, Ray and Philip Brown, "An Empirical Evaluation of Accounting Income Numbers," Journal of Accounting Research (Autumn 1968), pp. 159-178.

Banz, Rolf W., "The Relationship Between Market Value and Return of Common Stocks," Journal of Financial Economics (March 1981), pp. 3-18.

Banz, Rolf W. and Merton H. Miller, "Prices for State-Contingent Claims: Some Estimates and Applications," The Journal of Business (October 1978), pp. 653-672.

Bawa, V.S., "Optimal Rules for Ordering Uncertain Prospects," Journal of Financial Economics (March 1975), pp. 95-121.

Beaver, William H., "The Information Content of Annual Earnings Announcements," Empirical Research in Accounting: Selected Studies, 1968, Supplement to Journal of Accounting Research (1968), pp. 67-92.

Beaver, William H., "The Implications of Security Price Research for Disclosure Policy and the Analyst Community," Proceedings of the Duke Symposium on Financial Information Requirements for Security Analysis, (Duke University, Durham, North Carolina: December 1976), pp. 65-81.

Beaver, William H., Financial Reporting: An Accounting Revolution, (Englewood Cliffs, New Jersey: Prentice Hall, Inc., Contemporary Topics in Accounting Series, 1981).

Beaver, William H., and Roland Dukes, "Interperiod Tax Allocation, Earnings Expectations, and the Behavior of Security Prices," The Accounting Review (April 1972), pp. 320-332.

Beckers, Stan, "The Constant Elasticity of Variance Model and Its Implications for Option Pricing," The Journal of Finance (June 1980), pp. 661-673.

Ben-Zion, Uri, and Sol S. Shalit, "Size, Leverage, and Dividend Record as Determinants of Equity Risk," The Journal of Finance (September 1975), pp. 1015-1026.

Bhattacharya, Mihir, "Empirical Properties of the Black-Scholes Formula Under Ideal Conditions," Journal of Financial and Quantitative Analysis (December 1980), pp. 1081-1105.

Bhattacharya, Sudipto, "Nondissipitative Signaling Structures and Dividend Policy," The Quarterly Journal of Economics (August 1980), pp. 1-24.

Black, Fischer, "Fact and Fantasy in the Use of Options," Financial Analysts Journal (July-August 1975), pp. 36-41 and 61-72.

Black, Fischer and Myron Scholes, "The Valuation of Option Contracts and a Test of Market Efficiency," The Journal of Finance (May 1972), pp. 399-417.

Black, Fischer and Myron Scholes, "The Pricing of Options and Corporate Liabilities," Journal of Political Economy (May-June 1973), pp. 637-654.

Black, Fischer and Myron Scholes, "The Effects of Dividend Yield and Dividend Policy on Common Stock Prices and Returns," Journal of Financial Economics (May 1974), pp. 1-22.

Blattberg, Robert C. and Nicholas J. Gonedes, "A Comparison of the Stable and Student Distributions as Statistical Models for Stock Prices," The Journal of Business (April 1974), pp. 244-280.

Boyle, Phelim P., "Options: A Monte Carlo Approach," Journal of Financial Economics (May 1977), pp. 323-338.

Boyle, Phelim P. and A.L. Ananthanarayanan, "The Impact of Variance Estimation in Option Valuation Models," Journal of Financial Economics (December 1977), pp. 375-387.

Boyle, Phelim P. and David Emanuel, "Discreetly Adjusted Option Hedges," Journal of Financial Economics (September 1980), pp. 259-282.

Breeden, Douglas T. and Robert H. Litzenberger, "Prices of State-Contingent Claims Implicit in Option Prices," The Journal of Business (October 1978), pp. 621-651.

Brennan, Michael J., "The Pricing of Contingent Claims in Discrete Time Models," Journal of Finance (March 1979), pp. 53-68.

Brennan, Michael J. and Eduardo S. Schwartz, "The Valuation of American Put Options," The Journal of Finance (May 1977), pp. 449-462.

Brennan, Michael J. and Eduardo S. Schwartz, "The Case for Convertibles," Chase Financial Quarterly (Spring 1982), pp. 27-46.

Brittain, J.A., A Corporate Dividend Policy, (Washington D.C.: Brookings Institute, 1966).

Brown, Phillip, Allan Kleidon, and Terry March, "Earnings-Related Anomalies in Asset Returns," manuscript (University of Chicago, February 1980).

Charest, Guy, "Dividend Information, Stock Returns and Market Efficiency II," Journal of Finanial Economics (June-September 1978), pp. 297-330.

Chen, H.Y., "A Model of Warrant Pricing in a Dynamic Market," The Journal of Finance (December 1970), pp. 1041-1060.

Chang, Hui-Shyung and Cheng-few Lee, "Using Pooled Time-Series and Cross-Section Data to Test the Firm and Time Effects in Financial Analyses," Journal of Financial and Quantitative Analysis (September 1977), pp. 457-471.

Chiras, Donald P. and Steven Manaster, "The Information Content of Option Prices and a Test of Market Efficiency," Journal of Financial Economics (June-September 1978), pp. 213-234.

Christie, Andrew A., "Information Arrival, Equity Variances and Market Efficiency," working paper (Graduate School of Management, University of Rochester, Rochester, N.Y., May 1981).

Christie, Andrew A., "The Stochastic Behavior of Common Stock Variances: Value Leverage and Interest Rate Effects," Journal of Financial Economics (December 1982), pp. 407-432.

Cootner, P.H. (ed.), The Random Character of Stock Market Prices, (Cambridge, Massachusetts: M.I.T. Press, 1964).

Copeland, Thomas E. and J. Fred Weston, Financial Theory and Corporate Policy, (Reading, Massachusetts: Addison-Wesley Publishing Co., 1979).

Cox, John C. and Stephen A. Ross, "The Valuation of Options for Alternative Stochastic Processes," Journal of Financial Economics (January-March 1976), pp. 145-166.

Cox, John C., Stephen A. Ross, and Mark Rubinstein, "Option Pricing: A Simplified Approach," Journal of Financial Economics (September 1979), pp. 229-263.

Fama, Eugene F., "Efficient Capital Markets: A Review of Theory and Empirical Work," The Journal of Finance (May 1970), pp. 383-417.

Fama, Eugene F., Foundations of Finance, (New York: Basic Books, Inc. 1976).

Fama, Eugene F. and Harvey Babiak, "Dividend Policy: An Empirical Analysis," Journal of the American Statistical Association (December 1968), pp. 1132-1161.

Fama, Eugene F. and Merton A. Miller, The Theory of Finance, (New York: Holt, Rinehart & Winston, 1972).

Fama, Eugene F., L. Fisher, Michael Jensen, and Richard Roll, "The Adjustment of Stock Prices to New Information," International Economic Review (February 1969), pp. 1-21.

Finnerty, Joseph E., "The Chicago Board Options Exchange and Market Efficiency," Journal of Financial and Quantitative Analysis (March 1978), pp. 29-38.

Galai, Dan, "Pricing of Options and the Efficiency of the CBOE," unpublished Ph.D. thesis, (University of Chicago, 1975).

Galai, Dan, "Tests of Market Efficiency of the Chicago Board Options Exchange," The Journal of Business (April 1977), pp. 167-197.

Galai, Dan, "Characterization of Options," Journal of Banking and Finance (December 1977), pp. 373-385.

Galai, Dan, "On the Boness and Black-Scholes Models for Valuation of Call Options," Journal of Financial and Quantitative Analysis (March 1978), pp. 15-27.

Galai, Dan, "Empirical Tests of Boundary Conditions for CBOE Options," Journal of Financial Economics (June/September 1978), pp. 187-211.

Galai, Dan and R.W. Masulis, "The Option Pricing Model and the Risk Factor of Stock," Journal of Financial Economics (January/March 1976), pp. 53-81.

Galai, Dan and Mier I. Schneller, "Pricing of Warrants and the Value of the Firm," The Journal of Finance (December 1978), pp. 1333-1342.

Garman, Mark B., "An Algebra for Evaluating Hedge Portfolios," Journal of Financial Economics (October 1976), pp. 403-427.

Geske, Robert, "The Valuation of Corporate Liabilities as Compound Options," Journal of Financial and Quantitative Analysis (November 1977), pp. 541-552.

Geske, Robert, "The Valuation of Compound Options," Journal of Financial Economics (March 1979), pp. 63-81.

Geske, Robert, "A Note on an Analytical Valuation Formula for Unprotected American Call Options on Stocks with Known Dividends," Journal of Financial Economics (December 1979), pp. 375-380.

Geske, Robert, "Comments on Whaley's Note," Journal of Financial Economics (June 1981), pp. 213-215.

Gilster, John E., "Stock Options: Characteristics and Uses," Illinois Business Review (July 1979), pp. 10-12.

Glass, Gene V. and Julian C. Stanley, Statistical Methods in Education and Psychology, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1970).

Gleit, Alan, "Valuation of General Contingent Claims: Existence, Uniqueness, and Comparisons of Solutions," Journal of Financial Economics (March 1979), pp. 71-87.

Gonedes, Nicholas J., "Corporate Signaling, External Accounting, and Capital Market Equilibrium: Evidence on Dividends, Income, and Extraordinary Items," Journal of Accounting Research (Spring 1978), pp. 26-79.

Gonedes, Nicholas J. and N. Dopuch, "Capital Market Equilibrium, Information-Production, and Selecting Accounting Techniques," Studies on Financial Objectives: 1974, Supplement to Journal of Accounting Research (1974), pp. 48-129.

Gonedes, Nicholas J., N. Dopuch, and S.H. Penman, "Disclosure Rules, Information-Production, and Capital Market Equilibrium: The Case of Forecast Disclosure Rules," Journal of Accounting Research (Spring, 1976), pp. 89-137.

Gordon, Myron, The Investment and Valuation of the Corporation, (Homewood, Illinois: R.D. Irwin, 1962).

Gordon, Myron, "The Savings, Investment and Valuation of the Corporation," The Review of Economics and Statistics (February 1962), pp. 37-51.

Gordon, Myron, "Optimal Investment and Financing Policy," The Journal of Finance (May 1963), pp. 264-272.

Gould, J.P. and Dan Galai, "Transaction Costs and the Relationship Between Put and Call Prices," Journal of Financial Economics (July 1974), pp. 105-129.

Hakansson, Nils H., "Welfare Aspects of Options and Supershares," The Journal of Finance (June 1978), pp. 759-776.

Handjinicolaou, G., and Avner Kalay, "Wealth Redistributions or Informational Effects: An Analysis of Returns to the Bondholders and to the Stockholders around Dividend Announcements," manuscript (Baruch College, City University of New York and New York University, October 1982).

Higgins, Robert C., "Dividend Policy and Increasing Discount Rates: A Clarification," Journal of Financial and Quantitative Analysis (June 1972), pp. 1757-1762.

Hilliard, Jimmy E. and Robert A. Leitch, "Analysis of the Warrant Hedge in a Stable Paretian Market," Journal of Financial and Quantitative Analysis (March 1977), pp. 85-103.

Hogg, Robert V. and Allen T. Craig, Introduction to Mathematical Statistics, (New York: Macmillan, 1965).

Ingersoll, J.E., Jr., "A Theoretical and Empirical Investigation of the Dual Purpose Funds: An Application of Contingent Claims Analysis," Journal of Financial Economics (January/March 1976), pp. 83-123.

Jensen, Michael and William Meckling, "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure," Journal of Financial Economics (October 1976), pp.305-360.

Johnson, H.E., "Option Pricing When the Variance is Changing," manuscript, (University of California at Los Angeles, May 1979).

Joy, O. Maurice, Robert H. Litzenberger, and Richard W. McEnally, "The Adjustment of Stock Prices to Announcements of Unanticipated Changes in Quarterly Earnings," Journal of Accounting Research (Autumn, 1977), pp. 207-225.

Kalay, Avner, "Signaling, Information Content, and the Reluctance to Cut Dividends," Journal of Financial and Quantitative Analysis (November 1980), pp. 855-869.

Kalay, Avner, "Stockholder-Bondholder Conflict and Dividend Constraints," Journal of Financial Economics (July 1982), pp. 211-233.

Kirk, Roger E., Experimental Design: Procedures for the Behavioral Sciences, (Belmont, California: Brooks/Cole Publishing Co., 1968).

Klemkosky, Robert C., "The Impact of Option Expirations on Stock Prices," Journal of Financial and Quantitative Analysis (September, 1978), pp. 507-518.

Klemkosky, Robert C. and Bruce G. Resnick, "An Ex Ante Analysis of Put-Call Parity," Journal of Financial Economics (December 1980), pp. 363-378.

Lee, Cheng-few and Joseph Vinso, "The Single versus Simultaneous Equation Model in Capital Asset Pricing: A Synthesis," Journal of Business Research (Volume 8, 1980), pp. 65-80.

Latané, Henry A. and Richard J. Rendleman Jr., "Standard Deviations of Stock Price Ratios Implied in Option Prices," The Journal of Finance (May 1976), pp. 369-381.

Laub, P. Michael, "On the Informational Content of Dividends," The Journal of Business (January 1976), pp. 73-80.

Lee, Wayne Y., Ramesh K.S. Rao, and J.F.G. Auchmuty, "Option Pricing in a Lognormal Securities Market with Discrete Trading," Journal of Financial Economics (March 1981), pp. 75-101.

Lintner, J., "Distribution of Incomes of Corporations among Dividends," American Economic Review (May 1965), pp. 97-113.

MacBeth, James D. and Larry J. Merville, "An Empirical Examination of the Black-Scholes Call Option Pricing Model," The Journal of Finance (December 1979), pp. 1173-1186.

Malkiel, Burton G. and Richard E. Quandt, Strategies and Rational Decisions in the Securities Option Market, (Cambridge, Massachusetts: M.I.T. Press, 1969).

Manaster, Steven and Richard J. Rendleman Jr., "Option Prices as Predictors of Equilibrium Stock Prices," The Journal of Finance (September 1982), pp. 1043-1057.

May, Robert G., "The Influence of Quarterly Earnings Announcements on Investor Decisions as Reflected in Common Stock Price Changes," Empirical Research in Accounting: Selected Studies, 1971, Supplement to Journal of Accounting Research (1971), pp. 119-171.

May, Robert G. and Gary L. Sundem, "Research for Accounting Policy: An Overview," The Accounting Review (October 1976), pp. 747-763.

Mayers, David and Edward M. Rice, "Measuring Portfolio Performance and the Empirical Content of Asset Pricing Models," Journal of Financial Economics (March 1979), pp. 3-28.

McKean, Henry P. Jr., "Appendix: A Free Boundary Problem for the Heat Equation Arising from a Problem of Mathematical Economics," Industrial Management Review (Spring 1965), pp. 32-39.

Merton, Robert C., "Theory of Rational Option Pricing," Bell Journal of Economics and Management Science (Spring 1973), pp. 141-183.

Merton, Robert C., "Option Pricing When Underlying Stock Returns are Discontinuous," Journal of Financial Economics (January/March 1976), pp. 125-144.

Merton, Robert C., "On the Pricing of Contingent Claims and the Modigliani-Miller Theorem," Journal of Financial Economics (November 1977), pp. 241-249.

Merton, Robert C., Myron S. Scholes, and Mathew L. Gladstein, "The Return and Risk of Alternative Call Option Portfolio Investment Strategies," The Journal of Business (April 1978), pp. 183-242.

Mikkelson, Wayne H., "Convertible Calls and Security Returns," Journal of Financial Economics (September 1981), pp. 237-264.

Miller, Merton H. and Franco Modigliani, "Dividend Policy, Growth, and the Valuation of Shares," The Journal of Business (October 1961), pp. 411-433.

Modigliani, Franco and Merton H. Miller, "The Cost of Capital, Corporation Finance, and the Theory of Investment," American Economic Review (June 1958), pp. 261-297.

Noreen, Eric and Mark A. Wolfson, "Equilibrium Warrant Pricing Models and Accounting for Executive Stock Options," Journal of Accounting Research (Autumn 1981), pp. 384-398.

Ohlson, James A., "On Financial Disclosure and the Behavior of Security Prices," Journal of Accounting and Economics (December 1979), pp. 211-232.

Parkinson, Michael, "Option Pricing: The American Put," The Journal of Business (January 1977), pp. 21-36.

Patell, James M. and Mark A. Wolfson, "Anticipated Information Releases in Call Option Prices," Journal of Accounting and Economics (1979), pp. 117-140.

Patell, James M. and Mark A. Wolfson, "Preliminary Evidence on the Effect of Forthcoming Quarterly Earnings and Dividend Announcements on Call Option Prices," manuscript (Stanford University, March 1979).

Patell, James M. and Mark A. Wolfson, "The Ex Ante and Ex Post Price Effects of Quarterly Earnings Announcements," Journal of Accounting Research (Autumn 1981), pp. 434-458.

Pettit, R. Richardson, "Dividend Announcements, Security Performance, and Capital Market Efficiency," The Journal of Finance (December 1972), pp. 993-1007.

Pettit, R. Richardson, "The Impact of Dividend and Earnings Announcements: A Reconciliation," The Journal of Business (January 1976), pp. 86-96.

Phillips, Susan M. and Clifford W. Smith, Jr., "Trading Costs for Listed Options: The Implications for Market Efficiency," Journal of Financial Economics (June 1980), pp. 179-201.

Reilly, Frank K., "A Three-Tier Stock Market and Corporate Financing," Financial Management (Autumn 1975), pp. 7-15.

Reinganum, Marc R., "Misspecification of Capital Asset Pricing: Empirical Anomalies Based on Earnings' Yields and Market Values," Journal of Financial Economics (March 1981), pp. 19-46.

Roll, Richard, "An Analytic Valuation Formula for Unprotected American Call Options on Stocks with Known Dividends," Journal of Financial Economics (November 1977), pp. 251-258.

Roll, Richard, "Ambiguity When Performance is Measured by the Security Markets Line," The Journal of Finance (September 1978), pp. 1051-1069.

Ross, Stephen A., "Options and Efficiency," Quarterly Journal of Economics (February 1976), pp. 75-89.

Ross, Stephen A., "The Determination of Financial Structure: The Incentive Signaling Approach," The Bell Journal of Economics (Spring 1977), pp. 23-40.

Ross, Stephen A., "The Current Status of the Capital Asset Pricing Model (CAPM)," The Journal of Finance (June 1978), pp. 885-901.

Rubinstein, Mark, "The Valuation of Uncertain Income Streams and the Pricing of Options," The Bell Journal of Economics (Autumn 1976), pp. 407-425.

Samuelson, Paul A., "Rational Theory of Warrant Pricing," Industrial Management Review (Spring 1965), pp. 13-31.

Sandretto, Michael J., "The Influence of Firm Size On the Analysis of Accounting Information," unpublished Ph.D. thesis, (University of Illinois, 1979).

Schipper, Katherine and Rex Thompson, "The Impact of Merger-Related Regulations on the Shareholders of Acquiring Firms," forthcoming in Journal of Accounting Research (Spring 1983).

Schmalensee, Richard and Robert R. Trippi, "Common Stock Volatility Expectations Implied by Option Premia," The Journal of Finance (March 1978), pp. 129-147.

Schwartz, Eduardo S., "The Valuation of Warrants: Implementing a New Approach," Journal of Financial Economics (January 1977), pp. 79-93.

Shiller, Robert J., "Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?" The American Economic Review (June 1981), pp. 421-436.

Smith, Clifford W. Jr., "Option Pricing: A Review," Journal of Financial Economics (January-March 1976), pp. 3-52.

Smith, Clifford W. Jr., "Alternative Methods for Raising Capital: Rights Versus Underwritten Offerings," Journal of Financial Economics (December 1977), pp. 273-307.

Smith, Clifford W. Jr., "Applications of Option Pricing Analysis," in James L. Bicksler, (ed.), Handbook of Financial Economics (North Holland Publishing Co., 1979), pp. 80-121.

Spence, A.M. "Competitive and Optimal Responses to Signals: Analysis of Efficiency and Distribution," Journal of Economic Theory (March 1974), pp. 296-332.

Sprenkle, Case M., "Warrant Prices as Indicators of Expectations on Preferences," in: P.H. Cootner (ed.), The Random Character of Stock Market Prices, (Cambridge, Massachusetts: M.I.T. Press, 1964), pp. 412-474.

Stoll, Hans R., "The Relationship Between Put and Call Option Prices," The Journal of Finance (December 1969), pp. 801-824.

Taylor, Paul A., "The Information Content of Dividends Hypothesis: Back to the Drawing Board?" Journal of Business Finance and Accounting (Winter 1979), pp. 495-526.

Theil, Henri, Principles of Econometrics, (New York: Wiley, 1977).

Trippi, Robert R., "A Test of Option Market Efficiency Using a Random-Walk Valuation Model," Journal of Economics and Business (Winter 1977), pp. 93-98.

VanHorne, James C., Financial Management and Policy-5th ed., (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1980).

Verrecchia, Robert E., "On the Theory of Market Information Efficiency," Journal of Accounting and Economics (March 1979), pp. 77-90.

Watts, Ross, "The Information Content of Dividends," The Journal of Business (April 1973), pp. 191-211.

Watts, Ross, "Comments on 'On the Informational Content of Dividends,'" The Journal of Business (January 1976), pp. 81-85.

Watts, Ross, "Comments on 'The Impact of Dividend and Earnings Announcements: A Reconciliation,'" The Journal of Business (January 1976), pp. 97-106.

Weston, C.R., "The Information Content of Rights Trading," Journal of Business Finance and Accounting (Spring 1978), pp. 85-92.

Whaley, Robert E., "On the Valuation of American Call Options on Stocks with Known Dividends," Journal of Financial Economics (June 1981), pp. 207-212.

Whaley, Robert E., "Valuation of American Call Options on Dividend-Paying Stocks: Empirical Tests," Journal of Financial Economics (March 1982), pp. 29-58.

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