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Title An Empirical Study of Stock Price and Risk as They Relate
to Accounting Changes in Inventory Valuation Methods

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ABSTRACT

AN EMPIRICAL STUDY OF STOCK PRICE AND RISK AS
THEY RELATE TO ACCOUNTING CHANGES IN
INVENTORY VALUATION METHODS

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This thesis analyzes the relationship between the behavior of investors and changes in accounting methods for inventory valuation. Since financial information affects the interests of many economic agents including investors and creditors, such relationship is a major concern for the auditors and for the bodies responsible for development of financial accounting standards. Changes to and from Last-in, First-out (LIFO) method of inventory valuation have been selected for this study because such changes have a real economic impact on the firm through their tax implications.

Investor behavior with respect to the accounting changes is examined through empirical measurement of changes in market price and risk of stocks associated with the accounting changes. Price changes associated with the accounting changes are isolated from the market-wide price movements by using the Sharpe-Lintner capital asset pricing model. Risk of a stock is defined as the contribution of the stock to the rate of return variance on the market portfolio.

After a brief review of a few closely related studies, the effect of the accounting changes on reported income and economic value of the firm is analyzed. If stock price in the market follows the economic

value of the firm, changes to and from LIFO will be associated with price increase and decrease respectively. If market price follows the reported income, changes in price of stocks due to the accounting changes will be reversed. A research design which assumes that risk of stocks is constant over time is discussed and applied to the data. The risk of stocks can, however, be affected by the accounting changes through the effects of inflation and debt-equity ratio. Pre-change and post-change estimates of risk are compared and it is shown that changes in risk, if not accounted for, can contaminate the estimates of price changes associated with the accounting changes.

A procedure for testing stability of risk of stocks in the framework of random coefficient model is developed. The null hypothesis that the risk of the stocks was constant during the years surrounding the accounting change is rejected. The adaptive regression model is used to estimate changing risk of stocks. These estimates are examined for association with the accounting changes and are used to measure the price changes associated with the accounting changes. The data used are given in Appendices I and II.

Average stock price of the firms which changed to LIFO increased by about five percent during the fiscal year of the accounting change. During the following year, the price of these stocks showed no abnormal movements. The risk of these stocks decreased by about five percent during the two-year period surrounding the accounting change. Stock price of the firms which gave up LIFO decreased after the accounting

change and their risk also declined during the two-year period surrounding the accounting change.

Results of this study do not support the view that the market reacts adversely to the reduction in earnings caused by adoption of LIFO or reacts favorably to the increased earnings obtained by giving up LIFO. When an accounting change simultaneously affects the economic value and reported income of the firm in opposite directions, the market price seems to follow the former; and in this sense the market is not "fooled" by manipulation of the information system.

The assumption that the risk of firms is constant may not always hold. Changes in risk can be detected by the use of random coefficient models. The adaptive regression model can be used to estimate the behavior of an unstable risk parameter, and measure the association of price and risk of stocks with specific economic events.

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CHAPTER I

INTRODUCTION

1. INTENT OF THE THESIS

This thesis analyzes the relationship between changes in financial accounting procedures and investment behavior. This relationship is a major consideration in the development of standards of financial accounting. A better understanding of this relationship is also of direct interest to investors, the corporate management and the auditors.

The primary role of financial accounting is to provide information for the external control of economic entities. A variety of economic agents including investors, creditors, the state and the general public, use such information to exercise direct or indirect control over the enterprises. With the exception of some regulated industries, the information needs of owners and creditors of business enterprises have received special consideration in financial accounting as is clear from the Accounting Principles Board's Statement of Objectives of Financial Accounting and Financial Statements: "The basic purpose of financial accounting and financial statements is to provide quantitative information about a business enterprise that is useful to statement users, particularly owners and creditors, in making economic decisions."¹ Since financial accounting is so strongly oriented towards the needs of investors, an understanding of their behavior

¹Accounting Principles Board, Statement No. 4, para 73 in APB Accounting Principles, vol. 2.

with respect to financial accounting practices is necessary for improving reporting practices.

For investors, accounting statements are an important source of information as can be seen by the attention given to these statements and by the unusual stock market activity that is associated with their publication.² The effectiveness of control that investors can exercise on an enterprise depends on the quality of information they receive from various channels, including financial reports. Changes in financial accounting procedures may reduce the intertemporal and sometimes the inter-firm comparability, and hence the usefulness of financial statements. Investors are often suspicious of the motives that may lie behind the management decision to bring about the accounting changes. Since a matter of particular concern to the investors has been the possibility that accounting changes may be used by the management to manipulate the market prices, they are vitally interested in the changes in accounting procedures and the relationship of such changes to the behavior of stock prices in the market.

Given the corporate objective of maximizing the shareholders' wealth, the management is interested in maximizing the market value of the firm's stock. Accounting procedures, especially those which have a direct economic impact on the firm due to a tax advantage, such as Last-in, First-out (LIFO) method of inventory valuation, can be used by the management to this end.

²For evidence of unusual trading volume and price variability associated with the publication of financial statements, see Beaver (1968).

A better understanding of the relationship between accounting changes and investor behavior can be useful to the management in this respect. For example, it has been well recognized that given rising prices and stable or increasing inventory, the LIFO method of inventory costing leads to deferment of tax payments and consequently to an increase in the economic value of the firm. One possible explanation of the failure of most firms to adopt this method is that corporate managers are wary of reporting lower earnings, which result from non-realization of inventory holding gains under LIFO, for the fear of an adverse effect on stock price. If a study of the relationship between stock prices and accounting changes involving LIFO were to indicate that such adverse effect does not occur, managers would have little reason to hesitate in adopting LIFO on this ground.

A major concern of the auditing profession in the past decade has been to develop standards of financial reporting. Auditors have to judge and approve the admissibility of accounting procedures and the changes in accounting practices, if proposed by the management. For this purpose, auditors need information about the effect of accounting procedures and changes in accounting procedures on the interests of various economic agents in the society. Therefore the relationship between accounting procedures and behavior of prices in the stock market is an important consideration for the auditors.

The accounting changes between LIFO and First-in First-out (FIFO) methods of inventory valuation have been selected for analysis in this thesis for two reasons. First, these accounting changes are generally

accompanied by a direct economic impact on the firm through their tax implications.³ Second, the choice between these two procedures has been extensively though inconclusively debated in the accounting literature over the past three decades. The uniqueness conferred upon such accounting changes by the tax law and their controversial nature make them an interesting topic of investigation. The results of the investigation, it is hoped, will be useful to the various classes of decision makers mentioned above.

2. APPROACH

In this study the investor behavior is examined via market price at the aggregate level. The focus is on measuring the association between the accounting changes and the behavior of investors as reflected in ex post market prices of stocks. We shall argue that such analysis can capture some though not all the essential aspects of the relationships that may exist between financial reports and investor behavior. An alternative approach would have been to study the responses and decisions of individual investors when confronted with financial reporting data. While such an approach has the advantage of manipulative control over experimental variables, the absence of economic motivation, a competitive market and competitive sources of information in an experimental environment, make the results difficult to generalize to actual situations.

³ According to the tax law, firms cannot use LIFO for tax purposes unless they also use it for reporting purposes. The accounting changes involving LIFO are generally accompanied by the tax effects since for most firms a switch to LIFO is made to take the tax advantage, although theoretically it is possible for a firm to adopt LIFO only for financial statements.

The measurement of association between accounting procedures and investor behavior at the market level has several limitations. In the absence of control for other sources on information, it is not always possible to interpret the measure of association between financial reports and aggregate market behavior in unambiguous terms. The assumption of market efficiency, which is necessary for such measurement has remained controversial. Lack of manipulative control over the market variables renders the inference of a cause and effect relationship extremely difficult.

The association between the investor behavior at the market level and accounting events can be measured in terms of several factors including trading volume, price variability, price changes and changes in relative risk⁴ of stocks. Previous studies in the literature have examined the market response in terms of the first three of these factors. In this thesis, the relationship is first analyzed in terms of the price changes and later in terms of changes in relative risk.

The methodological approach of this thesis is primarily empirical and analytical. Economic models of price and relative risk

⁴ Several measures of risk of stocks have been proposed in the literature. According to the modern portfolio theory, the risk of a stock relative to the market portfolio is the measure appropriate for investment decisions. This definition is variously referred to as relative, market and systematic risk and is formally given in Chapter IV.2 of this thesis. The unqualified use of the term risk also refers to this definition. For details, see Fama and Miller (1972, Chapter 7).

changes associated with accounting changes are empirically tested on stock price data of the firms which actually changed their accounting methods to or from LIFO over a period of 21 years.

Some previously unused statistical procedures are presented and employed to detect and estimate changes in relative risk. Of necessity, Chapters VI and VII include a fair amount of econometric notation in the presentation of these models. Those who may not be interested in the details of the testing and estimation procedures can skip over Chapter VI and Chapter VII.2 without losing the continuity of the argument.

3. OUTLINE

Following this introductory chapter, the related accounting literature is reviewed in Chapter II to provide a perspective and framework for the methodology of this study.

In Chapter III, a brief description of various available methods for costing inventories is followed by a model of price changes for stocks of firms which change their accounting procedure in this respect. The model is conditional upon the extant tax laws of the United States and the assumption of continued inflation. The sources and a brief description of data used for empirical analysis are given in the last section of Chapter III.

Chapter IV presents a research design to measure the association between accounting and stock price changes. A justification for this design is provided in the light of the intent of the research (Chapter I.1) and the present state of the art (Chapter II). The stock

price data of the firms which changed their accounting methods are analyzed to draw conclusions about the relationship between stock prices and accounting changes. To provide a standard of comparison for these results, a random sample of stocks of comparable size is drawn from the population of firms listed on the New York Stock Exchange and their stock price data are analyzed around a hypothetical date of accounting change. The data are also analyzed by excluding the firms belonging to industries that are over represented in the sample in order to control for the industry effects. Smaller subsamples are analyzed to examine the homogeneity of the samples.

The research design used in Chapter IV assumes that the relative risk of stocks is stable over time and is not associated with accounting changes. The propriety and implications of this assumption are examined in Chapter V. It is argued that the research methodology adopted in Chapter IV is inadequate and the results obtained from this methodology are incomplete, if not misleading, in the presence of risk changes. Nevertheless, the results of Chapter IV have been given for the sake of comparability with other studies and to provide a point of departure and comparison with the modifications to this research design proposed later in Chapter VII. A model of association between changes in relative risk and accounting changes involving LIFO is presented and tested on preliminary estimates of average changes in relative risk of the sample firms. Due to changes in relative risk, the measured relationship between stock prices and accounting changes becomes a function of the time series data from which risk coefficients

are estimated. The effect of the choice of time span on estimated price changes is demonstrated by empirical estimation in Section 4 of Chapter V.

Chapter VI starts with a discussion of models of behavior of relative risk. Two random coefficient models for relative risk are presented. Procedures to detect the instability of relative risk in the framework of these models are given and their properties are examined with the help of Monte Carlo experiments. In Section 6 of this chapter, these procedures are applied to the stock price data of firms which changed their accounting procedures to present evidence on changes in the relative risk of these stocks.

The existence of changes in the relative risk of stocks, during the years surrounding a change in the accounting methods, observed in Chapters V and VI, calls for the use of estimation procedures which adequately take such changes into account. The measurement of association between accounting and stock price changes in Chapter IV is based on ordinary least square estimates of risk which do not allow for the possibility of change. Besides, as has been hypothesized in Chapter V, relative risk changes themselves might provide a measure of association between accounting changes and stock price behavior. Even if no such systematic relationships exist, abnormal price changes cannot be measured without allowing for changes in relative risk.

In Chapter VII, various techniques for the estimation of risk in a non-stable environment are reviewed and one is selected for

detailed presentation and use. The adaptive regression model⁵ is used to estimate the association of accounting changes with changes in price and relative risk of stocks.

In Chapter VIII, the results of the analysis of Chapters III through VII are summarized, synthesized and interpreted in the light of remarks made in the introductory and review Chapters I and II. Qualifications and limitations of the findings and methodology are also discussed. An attempt is made to place this study in perspective and to indicate directions for future research.

⁵See Cooley and Prescott (1972).

CHAPTER II

FINANCIAL REPORTING AND INVESTMENT DECISION:

A REVIEW

1. INTRODUCTION

Theory and practice of financial accounting have been developed on the premise that the published financial statements play an important role in forming investors' expectations about firms and the price of their stocks in the market. A priori support for the importance of financial statements is easily available. Considerable economic resources are spent on the preparation and distribution of these statements. Their release is eagerly awaited and promptly reported by the press and the wire services. Financial ratios, specially price earning ratios, are extensively used by the investors for the evaluation of stocks. High total earnings are, indeed, associated with high market value of the stock.

In recent years, the usefulness of financial statements has been increasingly subjected to empirical measurements. Investment behavior has been empirically analyzed at both the individual and the market level. In the next two sections, a few studies of each type are briefly reviewed.¹ Since this thesis is concerned primarily with changes in accounting procedures, the studies selected for review have a similar orientation. Some problems of empirical research design

¹See Hakansson (1971) and Dopuch (1972) for a review of empirical research in the sixties.

and inference are discussed in Section 4.

2. STUDIES OF INDIVIDUAL INVESTMENT BEHAVIOR

Experimental studies to examine investor behavior at the individual level have been conducted by Jensen (1966) and Dyckman (1966). Jensen designed an experimental field study of security evaluation by professional security analysts by supplying them data generated from different accounting procedures. He concluded that the accounting differences did affect the analysts' opinions of securities, primarily through their impact on earnings-per-share numbers.

Dyckman (1966) found in his study that the individual participants of his experiment reacted differently to data generated from different accounting procedures for inventory costing.

A major advantage of studying individual investment behavior in an experimental setting is the possibility of testing hypotheses about the existence of manipulative causality² between accounting procedures and investor behavior. However, the results from this approach are difficult to generalize for reasons such as subject selection, reward structure and experimental learning which are common

²See Rapoport (1953). He distinguishes manipulative causality from observational and postulational causality. The notion of manipulative causality between A and B implies "Make A occur and you will observe B" or "Prevent A from occurring and B will not occur". While it is possible to control the occurrence of A in experimental situations, it is not easy to do so in market level studies where the best that can be obtained is observational causality which implies "Watch for the occurrence of A and you will observe the occurrence of B".

to many behavioral experiments.³ A special objection to the generalization of results is the absence of a competitive market and competitive sources of information in the experimental environment. In a real market, accounting statements are only one of the many channels from which an investor receives information. The other channels include the press, the insiders and fellow investors. The value of financial statements evaluated in isolation from other sources of information may have very little validity in competitive markets.

3. STUDIES OF MARKET BEHAVIOR

A large number of empirical studies on the relationship between alternative accounting methods and aggregate market behavior have been published.⁴ Of the two basic approaches, the first is based on valuation theory in which various accounting variables are used to explain the stock price and price earnings ratio. Studies by O'Donnell, Summers, Mlynarczyk, Gonedes and Comiskey discussed below can be placed in this class. The second approach is based on the theory of capital market equilibrium. These models measure the price disequilibrium in individual stocks which, in turn, is examined for association with accounting events. Studies by Kaplan and Roll, Ball, Archibald and

³See Birnberg and Nath (1968) for a discussion of laboratory experimentation in accounting research.

⁴A broader set of literature is addressed to the measurement of association between accounting events, not necessarily accounting changes, and aggregate market behavior. Staubus (1965), Benston (1967) and Ball and Brown (1968) are representative examples. No attempt is made here to review these studies as they are closely related to those reviewed. For a broad review of empirical research in accounting, see Hakansson (1971).

Beaver and Dukes reviewed later in this section use this approach.

O'Donnell's first study (1965) compared mean price earnings ratios and trends of these means over time for three groups of electric utility firms over a twelve year period from 1949 through 1961. The first group of twelve firms had not switched to accelerated method of depreciation for tax purposes when the Revenue Act of 1954 first allowed its use. The second group of eighteen firms which adopted the accelerated method for tax purposes, had normalized the reduction in tax payments by carrying a deferred tax liability account. Another seven firms in the third group had also switched to the accelerated method for depreciation but had let the reduction in tax payments flow through the earnings reports. O'Donnell concluded that investors viewed the extra earnings reported by the last group of firms through an accounting device as real earnings. O'Donnell's (1968) second study reaffirmed his earlier conclusions.

Summers (1968) used the valuation approach to analyze the relationship between alternative accounting methods for investment tax credit and interperiod tax allocation, and market price. His conclusion that investors were indifferent to alternative accounting practices is in conflict with O'Donnell's.

Mlynarczyk (1969) constructed another valuation model with security price as a multiplicative function of accounting earnings, expected growth, revenues, debt equity ratio and two dummy variables--one for the listing on the New York Stock Exchange and the other for the use of flow through or deferred tax liability method by the firm.

The multiplicative model was transformed into a convenient linear form by logarithmic transformation. Out of the five years for which Mlynarczyk analyzed data, he concluded that accounting treatment made significant difference during the last three years only. Mlynarczyk's results support O'Donnell's conclusions.

Gonedes (1969) also examined the relationship of alternative treatments of interperiod tax allocation using a security price model based on Gordon's (1962) dividend capitalization model. His results "do not inevitably discredit the null hypothesis--may support alternative interpretations."

Comiskey (1971) analyzed the price earnings (P/E) ratios of eleven firms from the steel industry which had switched to accelerated depreciation in 1968 and compared them to the P/E ratios for a control group of steel firms which had not switched to accelerated depreciation. Since the reported earnings of the firms which switched had been artificially increased by the accounting change, he expected their P/E ratios to decline if the market price did not get affected by the management's tinkering with accounting. He found that the P/E ratios of these firms did in fact decline as compared to the control sample, and concluded that the market does not get fooled in this way.

There are two objections to the use of valuation models to measure the relationship between accounting events and stock prices. First, these models are formulated in terms of levels of price, income and other variables that are dominated by the scale factor. If different firms use different methods to record a certain type of

accounting event in a given period, we seek an answer to the following question. Do the investors value the stocks of these firms differently if they use different accounting methods? Usually there is such high cross sectional correlation between price levels and income levels that the effect of accounting difference (which is usually small) is very hard to detect. For example, Mlynarczyk's model had a coefficient of multiple determination in the range 0.8 to 0.85 and most of the explanatory power was provided by the scale variables such as income and revenue. The second objection to these models is that they consider the pricing of each stock as an isolated problem and ignore the cross sectional association that is known to exist among stock price changes.

The approach based on the capital market equilibrium model was first used by Fama, Fisher, Jensen and Roll (1969) in their study of the relationship between stock splits and stock prices. This approach and its justification are discussed in some detail in Chapter IV.2

Kaplan and Roll (1972) used Fama et al.'s model to study the relationship of accounting changes with respect to investment credit and depreciation, and stock price changes. They proposed and applied tests of significance on the measured relationship after taking the recent findings about the distribution of stock price changes into account. They did not find a statistically significant relationship between these accounting changes and stock price changes. Their results are, however, suggestive of a small price rise in stock price following a financial statement in which earnings have been boosted by making an accounting change. They summarize their findings in the following

words:

We have difficulty discerning any statistically significant effect that it has had on security prices. Relying strictly on averages, however, one can conclude that security prices increase around the date when a firm announces earnings inflated by an accounting change. The effect appears to be temporary, and certainly by the subsequent quarterly report, the price has resumed the level appropriate to the true economic status of the firm. In the present sample, firms that manipulated earnings seem to be doing poorly. If it is generally true, one would predict that earnings manipulation, once discovered, is likely to have a depressing effect on market price because it conveys an unfavorable management view of the firm's economic condition. (p. 245)

As Kaplan and Roll point out, the mere fact that the management decided to change the accounting procedure, may have information for the market and may affect the prices. This is an important issue and is discussed in greater detail in Chapters IV and VIII.

Another study was conducted by Archibald (1972) on 65 firms which changed their method for depreciation from accelerated to straight line using a methodology quite similar to Kaplan and Roll's. Though he did not conduct formal tests of significance, he concluded that " the [depreciation] switchback announcement and resultant profit improvement apparently had no immediate substantial effect on stock market performance." (p. 30)

Ball (1972) analyzed the relationship between stock prices and a variety of accounting changes by various firms over a period of fourteen years. He used Black's (1972) two factor model instead of the market model.⁵ The descriptive validity of the two factor model is still controversial. This issue is discussed in Chapter IV.2.

⁵The market model is discussed in Chapter IV.2.

Ball also questions the assumption about the stability of relative risk inherent in Fama, et al.'s methodology. The issue of changes in relative risk is dealt with in Chapters V, VI and VII of this study. Conclusions of Ball's study "overwhelmingly support the notion of market efficiency, in that income manipulations appear to have no effect on market efficiency" (p. 40)

Beaver and Dukes (1972) compared the association of cash flow and two income numbers, arrived at by two different treatments of interperiod tax allocation, with changes in market price stocks. In this study, no accounting changes had actually been effected or reported by the firms. The authors computed the second income figures from the published earnings and other data. They concluded that "deferral earnings are most consistent with the information set used in setting security prices, while cash flow is least consistent" (p. 331). A key objection to this approach is that the results can be highly dependent on the income expectation models used. Though Beaver and Dukes used several expectation models, their descriptive validity is untested. The reason why this and several of the studies cited above were conducted on the deferred tax accounting issue is that the firms which defer taxes, give enough information in the financial statement to enable anybody to compute the other income number at little cost. Such information is generally not given for other accounting changes.

Beaver and Dukes' criterion of selecting the accounting method which has the highest correlation with stock prices, has some logical circularity as Dopuch (1972) points out:

We are supposed to provide information which is useful to the market in arriving at prices of securities. But does that mean that changes in the accounting income series should be perfectly correlated with changes in the price series? I can think of an accounting measure of income which would be perfectly correlated with the price series--namely, income is the change in the "value" of the common stock of the firm! We really do not know how the market uses presently reported accounting income numbers and how they would use alternative income numbers if these were reported. Of course, once we did report several different constructs of income, we could determine whether one construct seems to be used by the market more than another. However, I am not sure that such evidence would be sufficient to argue that the preferred alternative should be the only one reported thereafter. (p. 28-29)

4. PROBLEMS OF RESEARCH DESIGN AND INFERENCE

The review given above is limited to the studies directly concerned with the relationship between accounting changes and investment decision. Though many important studies concerned with other accounting events are not specifically mentioned, most important research approaches in this area have been covered. The following remarks in this section summarize the strengths and weaknesses of these approaches and give a preview of the methodological innovations of this study which, it is hoped, overcome some of the weaknesses of the current approach to the study of investment decision at the aggregate market level.

A basic problem of financial reporting is to understand whether and in what way, alternative accounting procedures affect the behavior of investors in the manipulative sense of the word. Empirical observation reveals only recurring associations. Since a researcher who works with the market data does not have manipulative

control over the variables under study, the establishment of a cause and effect relationship is extremely difficult. Inference of a causative relationship can be used as a working rule only so long as nothing to the contrary is observed. Results from different empirical studies in this area of accounting have been so much in disagreement that a cause and effect relationship seems premature.

Experimental studies have the advantage of manipulative control over various variables which might affect the investment decision. Unfortunately, lack of realism limits the usefulness of the experimental approach. For example, it is difficult to argue that investor decisions arrived at in isolation would be similar to the decisions taken in a competitive market situation. Many competitive sources of information interact in the market environment and failure to include them in the experiment is a serious limitation of such studies. Current knowledge of the structure of the information market and the communication network between investors and firms does not permit their formal modeling in experimental designs.

The capital market equilibrium based approach to the study of relationship between accounting changes and investor behavior also has a few weaknesses. The capital asset pricing model of Sharpe (1964) and Lintner (1965) has been under attack recently.⁶ The debate about the efficiency of capital market has entered the into accounting literature along with attempts to use the market model for inference

⁶See Black (1972), Miller and Scholes (1972), Black, Jensen and Scholes (1972) and Blume and Friend (1973).

on accounting issues. Gonedes (1972) and Beaver (1972) give representative expositions of the efficient market point of view in the accounting literature. Some theoretical arguments have been advanced as to why capital markets should be efficient, and considerable empirical evidence has been interpreted to support the efficiency hypothesis.⁷ Downes and Dyckman (1973) review the evidence which questions an absolutist view of market efficiency. They also mention that market based studies in accounting have largely ignored the heterogeneity of the individual investor expectations which has important implications for policy on accounting information.

Financial statements can be viewed as a link in the communication network between the firms and the investors. In studies of the role of financial statements, other channels of communication have been largely ignored. In empirical studies of the market behavior, substantial price changes have often been observed earlier than the release of the financial statement. Such price changes have been attributed to the flow of information through these other channels. It seems unlikely that the role of financial accounting in the capital market can be properly understood without a broader understanding of the communication network between the firm and the market. Some recent theoretical work by Gonedes (1973) and Demski (1972) is related to this problem.

A critical assumption in the market based research designs has

⁷See Fama (1970), for a review of this literature.

been the stability of the relative risk of firms over time. Ball (1972) proposed a modification to the research design in which he dropped this assumption. His methodology is examined in Chapter V of this study. In Chapter V and VI, evidence is presented to show that the assumption of the stability of risk is not valid. Effects of this erroneous assumption on inference are demonstrated in Chapter V and an alternative research design to take the changes in relative risk into account, is presented and used in Chapter VII.

A consequence of the assumption of the stability of relative risk has been to ignore the possibility that the relationship between accounting information and price behavior could also be studied in terms of changes in relative risk. So far market based studies have attempted to measure the abnormal price changes which might be associated with accounting information. It has been argued in Chapter V that in addition to the measurement of abnormal price changes, relative risk changes can provide another useful framework for study of this relationship. A theory of such a relationship is presented in Chapter V and empirically tested in Chapters V and VII.

Limitations of the market based approach to study the relationship between accounting changes and market price behavior, are many. These have been recounted in this chapter to place in perspective this study which also uses the aggregate market based research design to investigate the relationship of the market with another accounting change--namely, the accounting changes involving the use of LIFO method

of inventory costing. An attempt has been made in this study to remedy some of the limitations of the market based approach as it has been applied in the literature. Limitations of this approach which have not been overcome in this study, shall be used to qualify the interpretations of the results in Chapter VIII.

CHAPTER III

CHANGES IN ACCOUNTING FOR INVENTORY COSTING

1. INTRODUCTION

The existing literature on the role of financial reporting in investment decision has been briefly reviewed in Chapter II. In this chapter, a specific set of accounting procedures is considered--procedures for costing of inventory for financial reporting and tax purposes. Several methods of inventory costing are possible under the generally accepted accounting principles. Many business firms are known to have switched from one procedure to another. Such changes affect the income, cash flow, and asset and liability entries in the financial statements of these firms. A brief description of these accounting procedures for inventory costing, and their classification into two categories is given in Section 2 of this chapter. In Section 3, the effect of the accounting changes on reported income, net cash flow and tax liability is analyzed. Two hypotheses about the relationship between these accounting changes and stock price changes are presented in Section 4. Data on the firms which made these accounting changes, and their sources and characteristics are discussed in Section 5. The hypotheses are tested on the data in Chapter IV.

2. ACCOUNTING FOR INVENTORY COSTS

Generally accepted procedures for pricing of inventories rely on their cost or market value or on a combination of the two. The basis for determining the cost is acquisition cost. The phenomenon of

price changes combined with the lack of identifiability of individual units of inventory make it necessary for the accountant to make some cost flow assumptions when matching costs with revenue. In the absence of price changes, there would be no need to make any cost flow assumptions. Similarly, if each unit of inventory was identifiable and keeping account of its acquisition cost was not too costly, it would not be necessary to make an assumption about inventory cost flows.

Though a large variety of cost flow assumptions are used in practice, most firms use one of the following three:¹

1. First-in First-out (FIFO)
2. Moving Average Cost (MAC)
3. Annual Last-in First-out (LIFO)

The FIFO method assumes that inventory acquisition costs flow through in chronological order. If at any time x units remain in the inventory, their cost is the acquisition cost of the latest x units purchased. This requires a record of the quantity, unit cost and date of each lot purchased. In the Moving Average Cost method, inventory is valued at a single acquisition cost which is a moving average of the acquisition cost of individual lots. The LIFO method assumes that the cost of goods sold should be derived from the acquisition cost of the latest purchases. It is usually applied on a yearly rather than on

¹ According to the 1972 edition of Accounting Trends and Techniques, of the 545 business firms which disclosed their cost flow assumptions in their annual reports, 40 % used First-in First-out, 27 % used Moving Average Cost and 18 % used Last-in First-out. This trend goes back as far as 1946 when a similar survey indicated that these three methods accounted for a total of 85 % of the firms surveyed.

daily or monthly basis.

All three methods separate physical flow of inventories from cost flows. This separation is further justified in terms of the objectives which the financial statements are expected to fulfil. For example, LIFO has been justified on the ground that it provides a more realistic income statement, even though it is achieved at the expense of making some balancesheet entries unrealistic.

In order to analyze the effect of change in cost flow assumptions on income and cash flow, these three cost flow assumptions can be placed in two categories. FIFO and MAC have much more in common with each other than with LIFO. In both FIFO and MAC inventory holding gains (losses) are realized, albeit with different amounts of time lag, and included in the reported income. Inventory entries on the balance sheet remain much closer to the market value of inventory than is the case with LIFO. The LIFO method, if used for long during periods of large price changes, can lead to a balance sheet whose inventory entry has little relationship to the current market value of the inventory. Unless year-end inventories decrease, LIFO does not allow for the inclusion of inventory holding gains in the income statement.

In the following analysis, no distinction is made between FIFO and MAC assumptions of cost flows and both these methods are referred to as FIFO in the rest of the study. The effects of changes from LIFO to FIFO and vice versa on income, cash flow and tax liability are analyzed in the next section.

3. EFFECT OF ACCOUNTING CHANGES ON INCOME AND CASH FLOWS

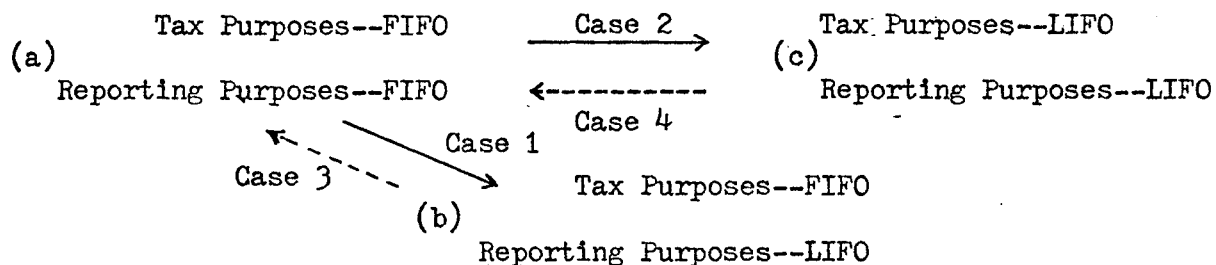
Accounting changes for inventory can occur between any two of the following three states:

- (a) FIFO used for both reporting and tax purposes
- (b) FIFO used for tax and LIFO for reporting purposes
- (c) LIFO used for both reporting and tax purposes

A total of six different transitions, from any one of the three to the remaining two, can occur among these three states. The transitions between states (b) and (c) do not involve a change in accounting for reporting purposes and the information about such transitions does not become available to the market through the financial statements. The remaining four transitions are shown in Figure III.1 where arrows to the right in firm line depict transitions towards adoption of LIFO and arrows to the left in broken line show the transitions involving abandonment of LIFO.

Figure III.1

Transitions To and From LIFO



The effect of each of these transitions on the reported earnings, tax

liability and economic value of the firm can be analyzed under the following assumptions:²

- (a) The market price of the goods ordinarily included in the inventory of the firm is increasing. Since commodity prices in the United States have been increasing over the past three decades,³ it is very likely that this assumption holds for most firms. The existence of a few firms for which it may not hold need not be of much concern since a cross sectional analysis over a wide variety of firms should bring out the strong inflationary trend experienced by the economy.
- (b) Accounting changes are not accompanied by a change in the internal decision process of the firm which may systematically alter the reported earnings or value of the firm. Some evidence to support this assumption is provided by Dyckman (1964).
- (c) The marginal tax rate of the firm is positive.
- (d) The discounted cash flow concept of valuation of firm is used. Miller and Modigliani (1961) have shown that other major approaches to valuation (current earnings plus future investment opportunities, stream of dividends and stream of earnings) are essentially equivalent under perfect capital markets and rational behavior.

²See Cerf (1956), Holdren (1964) and Most (1967) for an analysis of the effect of LIFO on income and various ratios.

³The Wholesale Price Index of the Bureau of Labor Statistics increased at an average annual rate of 3.43 % during the 32 years since 1939 when the Internal Revenue Act of 1938 first permitted the use of LIFO for tax purposes. The price level dropped in only 5 of these 32 years.

(e) Firms using LIFO maintain stable or increasing year-end inventory in order to prevent the realization of inventory holding gains.

(f) Reported earnings in the following discussion include the inventory holding gains realized at the time of accounting change even if such gains were directly added to the retained earnings or shown as extraordinary items.⁴

Under these assumptions, the effect of the four transitions is analyzed as follows:

Case 1. Adopting or extending the use of LIFO for reporting purposes only.

This represents a transition from state (a) in which LIFO is not used to state (b) in which LIFO is used for reporting purposes only. Since there is no change in tax liabilities, both present and future net cash flows and hence the value of the firm remain unchanged. The adoption of LIFO for reporting purposes prevents the realization of inventory holding gains and their inclusion in the reported earnings. Thus the current and future reported earnings are lower to the extent of the inventory holding gains which would have been realized under FIFO.

Case 2. Adopting or extending the use of LIFO for both tax and reporting purposes.

This represents a transition from state (a) to state (c). Non-realization of inventory holding gains under LIFO results in

⁴ APB Opinion 20 which came into effect in August 1971 calls for much more explicit disclosure of accounting changes from LIFO to other methods than had been required earlier. The data for this study are taken from the period 1946 to 1966 when these rules were not applicable.

lower taxable and reported earnings. If the marginal tax rate of the firm is positive, the tax liability of the firm is also lower. Even if inventory holding gains are realized in a subsequent period, tax payments on these gains are postponed until such time. This amounts to an interest free loan to the firm from the tax authority. The value of the firm increases because the present value of net cash flows to the firm is higher. Thus the reported earnings and the economic value of the firm change in opposite directions.

Case 3. Wholly or partially abandoning LIFO used for reporting purposes only.

This represents a transition from state (b) to state (a). As in Case 1, no change is involved for tax purposes with the result that the tax liability and the current and future net cash flows remain unchanged. Since previously unreported inventory holding gains are realized, current and future reported earnings are higher than they would have been if the accounting procedure had not changed. (See assumption f and footnote 4.)

Case 4. Wholly or partially abandoning the use of LIFO for both tax and reporting purposes.

This represents a transition from state (c) to state (a). Realization of inventory holding gains results in higher reported as well as taxable earnings in the current and future accounting periods. (See assumption f and footnote 4.)

Increased tax liability on realized inventory holding gains reduces the economic value of the firm. Thus the changes in economic value and reported earnings are in opposite directions.

These results are summarized in Table III.1. In announcing the accounting changes, most firms did not indicate whether the change extended to accounting for tax purposes. For this reason it is not possible to classify all firms which made such accounting changes into one of these four cases. The available information does, however, permit a classification of these firms into two groups:

Group A - consists of firms which adopted or extended the use of LIFO (Cases 1 and 2).

Group B - consists of firms which partially or wholly abandoned the use of LIFO in favor of FIFO or Moving Average Cost (Cases 3 and 4).

4. HYPOTHESES

The advantage of this grouping of accounting changes into Group A and Group B can be seen immediately from Table III.1. For all accounting changes in Group A (Cases 1 and 2), the change in reported earnings is negative while the change in the value of the firm is zero or positive. If market expectations are formed on the basis of reported earnings, the market price of these stocks should decline as a result of the announcement of the accounting change. On the other hand, if these expectations are formed on the basis of the economic value of the firms, the market value of the firms in Group A should increase or remain unchanged.

Table III.1

Effect of the Accounting Changes on Income and Economic Value of the Firms

<u>Group</u>	<u>Case</u>	<u>Cash Out Flows</u>	<u>Tax Liability</u>	<u>Reported Earnings</u>	<u>Economic Value</u>
A	1	Unchanged	Unchanged	Lower	Unchanged
	2	Lower	Lower	Lower	Higher
B	3	Unchanged	Unchanged	Higher	Unchanged
	4	Higher	Higher	Higher	Lower

Similarly for the accounting changes included in Group B, the change in the economic value of the firms involved is zero or negative but the change in the reported earnings is positive. If the market's expectations are formed on the basis of reported earnings, the market price of stocks of firms should increase. If on the other hand, these expectations are formed on the basis of the economic value of the firms, the market price of all firms in Group B should either decline or remain unchanged.

If the stock price changes associated with the accounting changes can be measured, the following two hypotheses about their relationship can be tested:

Hypothesis 1. Market's expectations about a firm are formed on the basis of the real economic value of the firm. Market price reflects this value, and accounting changes which increase the economic value of a firm are associated with an increase in the firm's market price.

Hypothesis 2. Market's expectations about a firm are formed on the basis of reported earnings. If an accounting change causes a change in the reported earnings, the market price will be affected accordingly even if the effect of the accounting change on the economic value of the firm is zero or in the opposite direction.

If the accounting changes for Group A are found to be associated with an increase in the market price, such evidence will support Hypothesis 1.

If accounting changes for Group B are found to be associated with a decline in market price, this will also support Hypothesis 1. But if accounting changes are associated with a decline in price for Group A firms and with a rise in price for Group B firms, Hypothesis 2 will be supported by such evidence. The data used for empirical analysis and testing of these and other hypotheses in subsequent chapters are described in the next section.

5. DATA

Three kinds of data are needed for this study--the identity of firms which changed their accounting procedure, date of change and stock price relatives for the years surrounding the date of accounting change. Sources, collection procedures and certain characteristics of the data are given below.

IDENTITY OF FIRMS

Names of the firms which adopted, extended or abandoned the use of the LIFO method of inventory valuation were obtained from the 1946 to 1966 editions of Accounting Trends and Techniques (published by the American Institute of Certified Public Accountants). The initial sample had 199 firms (Group A - 165; Group B - 34) including multiple counts for the firms which changed their accounting method more than once during the period 1946-1966. A total of 44 firms (Group A - 36; Group B - 8) were dropped from the sample for the following reasons:

1. They could not be identified by name.
2. Examination of the annual report indicated that rather than

adopting LIFO, they had merely acquired a subsidiary using this method.

3. They were not listed on the New York Stock Exchange and their stock price data was not available on the Center for Research Security Prices (C.R.S.P.) Monthly Price Relative File.

Various parts of this study require different amounts of data for analysis. These data requirements further reduce the sample size. Such reductions are indicated at appropriate places in this study. In effect, 155 is the maximum sample size (Group A - 129; Group B - 26) for any part of this study. Names of these firms are given in Appendix I.1.

The selection criteria mentioned above may introduce the familiar C.R.S.P. bias towards larger and successful firms in this sample. Though the firms listed on the New York Stock Exchange are not representative of all business firms, they are fairly representative of a major sector of the economy to which this study is directed. Therefore this bias is not of serious concern.

The Industry Profile and Multiple Counts Profile of the sample of firms are given in Appendices I.2 and I.3 respectively.

DATE OF CHANGE

It is difficult to know precisely when the information about an accounting change becomes available to the market. Some previous studies⁵

⁵Benston (1967) and Kaplan and Roll (1972) used earnings announcement dates from the Wall Street Journal Index. Ball (1972) assumed that changes become known three months after the end of the accounting period for the firms whose date of publication of annual reports was not available.

have justified the date of formal announcement of earnings for this purpose. Wall Street Journal Index, the principal source of such information, is not available for 1940's and early 1950's when most firms in the sample changed their accounting procedure. Therefore the last day of the fiscal year during which the change was brought about is used as the base date for accounting change and for cross sectional alignment of data. The exact date of earnings announcement is unlikely to make a substantial difference to the results of this study. Most earnings announcements come within one or two months after the end of the fiscal year and any effect is likely to be captured in the monthly price return data used in this study. In light of the following remarks by Davidson (1968), end of the fiscal year might actually be a better measure of the availability of information to the market than the date of the formal announcement of earnings:

Effective earnings announcements are often made prior to the date that the announcement formally appears in The Wall Street Journal. Under pressure from stockholders or financial analysts, a company may release hard, preliminary estimates of annual earnings in the 4-8 week period about the end of the fiscal year. Further, leaks on actual earnings are known to occur. Earnings are usually known roughly within a company by 15 days after fiscal year-end--when the books are closed. Within 25 days after fiscal year-end, audit fieldwork will usually be sufficiently completed that the final figure is known. While there are no formal statistics on leaks and their timings, a company is able to leak information at an early date. The effect of such leaks is, of course, to diminish the effect observed on the WSJ date.

The last date of the fiscal year of each firm was obtained from Moody's Industrial Manual and is given in Appendix I.1. The date of change profile of the sample is given in Appendix I.4

STOCK PRICE DATA

Monthly stock price returns are available on the University of Chicago's Center for Research in Security Prices Monthly Price Relative File. Fisher's Arithmetic Index⁶ is used as the index of returns on the market portfolio.

⁶Fisher (1966)

CHAPTER IV

ACCOUNTING AND STOCK PRICE CHANGES

1. INTRODUCTION

Hypotheses about the relationship between changes in accounting for inventory costing and changes in stock prices have been discussed in Chapter III. Data on the firms which made such changes during the 21 year period from 1946 to 1966 have also been presented. In Section 2 of this chapter, a research design is presented to measure the relationship between accounting changes and stock price changes and to test the above mentioned hypotheses. An underlying assumption of this design is that the relative risk of firms is stable over time and does not change when a change in accounting methods is brought about. Though the validity of the stability assumption is not self evident, the research design has been used extensively in the literature. Application of this research design to the data is useful not only for comparison of the results of this study with the results of other studies, but also for comparison with the results reported in Chapter VII which uses an alternative research design in which the stability of relative risk is not assumed.

Section 3 of this chapter presents the results from analysis of the data by the methodology described in Section 2. Interpretation of the results and the summary are given in Section 4.

2. RESEARCH DESIGN

Changes in the price of individual stocks may be associated with a large number of economic events and actions of various investors in

the competitive market. In order to isolate the component of price changes which might be associated with a specific event (changes in accounting procedure in this study), a research design based on the theory of capital market equilibrium has been proposed by Fama et al. (1969). This methodology has been used, among others, by Benston (1967), Ball and Brown (1968), Kaplan and Roll (1972) and Archibald (1972) to study various accounting events. A brief description of this research design is presented in this section.

Events that affect the stock price of a firm in a competitive market can be placed into two classes, (a) those which affect the price of all the securities in the market¹ and (b) those which are unique to the particular firm. Sensitivity of the price changes of a stock to the price changes for the market as a whole, is called risk coefficient of the stock. By measuring the market wide price movements and the sensitivity of a given stock to the market movements, the individualistic component of the changes in the price of the stock, caused by events unique to the firm, can be isolated. King (1966) has shown that a common (market) factor accounts for about half of the price change variance of individual stocks on average. Model (1), usually referred to as the market model, relates R_{jt} , the observed return² on stock j in

¹Operational definition of the market has been limited to the New York Stock Exchange in the empirical analysis, primarily due to unavailability of data in readily usable form for other markets for securities, commodities and real estate etc.

²Return on security j in period t is defined as the total relative change in the price of the stock after adjustment for cash and stock dividends and splits. If P_{jt} is the price of stock j at the end of period t , adjusted for splits, and D_{jt} is the dividend distributed during this period, return R_{jt} is equal to $((P_{jt} + D_{jt}) / (P_{j\ t-1}) - 1)$. To transform this finite period return to continuously compounded

period t , to R_{mt} , the observed market factor in period t , and the unobserved individualistic factor u_{jt} through a simple linear relationship.

$$(1) \quad R_{jt} = \alpha_j + \beta_j R_{mt} + u_{jt}$$

where

$$E(u_{jt}) = 0$$

$$\text{Cov}(u_{jt}, R_{mt}) = 0$$

$$\text{Cov}(u_{jt}, u_{it}) = \begin{cases} 0 & \text{for } j \neq i \\ \sigma_u^2 & \text{for } j = i \end{cases}$$

$$\text{Cov}(u_{jt}, u_{js}) = \begin{cases} 0 & \text{for } t \neq s \\ \sigma_u^2 & \text{for } t = s \end{cases}$$

α_j is a constant and β_j is the sensitivity of stock j to the market factor.

This model is closely related to, but not identical with, the capital asset pricing model (2) of Sharpe (1964), Lintner (1965) and Mossin (1966) which specifies the conditions of the capital market equilibrium in terms of the first two moments of the probability distribution of stock price returns.

$$(2) \quad E(\tilde{R}_{jt}) = R_{ft} + (E(\tilde{R}_{mt}) - R_{ft}) \cdot \frac{\text{Cov}(\tilde{R}_{jt}, \tilde{R}_{mt})}{\text{Var}(\tilde{R}_{mt})}$$

where

E is the expected value operator

\sim indicates random variable

\tilde{R}_{jt} is the return on security j in period t

basis, $\log_e((P_{jt} + D_{jt})/(P_{j,t-1}))$ is used as the operational definition of return.

R_{ft} is the risk free rate of return in period t

\tilde{R}_{mt} is the return on the market portfolio

Unlike the market model which specifies a relationship between realized values, the capital asset pricing model is formulated in terms of mean and variance of the return distribution. While model (1) is a specification of the stochastic generating process for stock price changes, model (2) is an equilibrium condition on expected price changes. By using

$$(3) \quad \lambda_{jt} = \frac{\text{Cov}(\tilde{R}_{jt}, \tilde{R}_{mt})}{\text{Var}(\tilde{R}_{mt})}$$

model (2) can be rewritten as,

$$(4) \quad E(\tilde{R}_{jt}) = (1 - \lambda_{jt}) R_{ft} + \lambda_{jt} E(\tilde{R}_{mt})$$

β_j in model (1) and λ_{jt} in model (4) can be approximately equal ³ if: (a) variance of the market factor R_{mt} is equal to the variance of the return on the market portfolio \tilde{R}_{mt} , (b) no security represents a very large fraction of the market portfolio, (c) variance of the individualistic factor u_{jt} is not much larger than the variance of the return on the market portfolio and (d) sensitivity β_j of stock j to market factor and λ_{jt} are unchanged over time. King (1966) and Blume (1968) have indicated that the first three assumptions are

³See Jensen (1969) pp. 180-181

not unreasonable. The evidence on the last assumption is not so strong. Most studies (except Ball (1972)) have used this assumption in measuring the relationship of various accounting events to stock price changes. In this chapter the data are analyzed assuming that the sensitivity of stocks to the market factor is constant over time. Issues, evidence and implications related to this assumption are the subject matter of Chapters V, VI and VII. An additional assumption that the risk free interest rate R_{ft} is constant will imply that α_j , the intercept of model (1) is approximately equal to $(1 - \lambda_{jt}) R_{ft}$. Kaplan and Roll (1972) and Bogue (1972) found that if the riskless rate is assumed to be constant, it makes very little difference to the estimates of α_j and β_j .

The above discussion implies that since sensitivity β_j in model (1) is equal to the relative risk λ_{jt} of stock j in the market portfolio, the market factor in (1) can be replaced by the return on the market portfolio. Thus equation (1) is a simple regression of R_{jt} , the ex post return on stock j in period t on R_{mt} , the ex post return on the market portfolio in period t . Since monthly price data is used in this study, each period corresponds to a month. The month during which the change occurred is given time index zero ($t = 0$) for each accounting change in the sample. Thus period t for all accounting changes does not correspond to the same chronological month.

In this study, the estimates of α_j and β_j are obtained from ordinary least square regression for each stock by using a minimum of 24 to a maximum of 120 months of data within six years before and

six years after the date of accounting change. Twelve months of data on either side of the accounting change are excluded from the regression because of the suspicion that residuals during this period may have non-zero expectations which may bias the parameter estimates. Let $\hat{\alpha}_j$ and $\hat{\beta}_j$ be the ordinary least square estimates of α_j and β_j respectively from the simple linear regression model,

$$(5) \quad R_{jt} = \alpha_j + \beta_j R_{mt} + u_{jt} \quad (t = -71, \dots, -12, 13, \dots, 72)$$

Under the set of assumptions given above with model (1), $\hat{\alpha}_j$ and $\hat{\beta}_j$ are the minimum-variance-unbiased estimates of α_j and β_j . Note that the 24 monthly observations ($t = -11, \dots, 12$) are excluded from the regression. For these 24 months, the residual price changes \hat{u}_{jt} which represents the component of price change specific to stock j is computed using estimates $\hat{\alpha}_j$ and $\hat{\beta}_j$.

$$(6) \quad \hat{u}_{jt} = R_{jt} - \hat{\beta}_j R_{mt} - \hat{\alpha}_j \quad (t = -11, -10, \dots, 12)$$

Now define \bar{u}_t , the average residual for month t , t being measured with respect to the month of accounting change which is designated as month 0.

$$(7) \quad \bar{u}_t = \frac{1}{N} \sum_{j=1}^N \hat{u}_{jt} \quad (t = -11, \dots, 12)$$

where N is the number of stocks. \bar{u}_t is also referred to as the abnormal return in period t because this is the return obtained on an equally weighted portfolio of the N stocks under study, over and above the market return after adjustment for risk. The cumulative

abnormal return on this portfolio starting month -11 up to month t is denoted by U_t ,

$$(8) \quad U_t = \sum_{i=-11}^t \bar{u}_i \quad (t = -11, \dots, 12)$$

If it is assumed that the market reacts immediately and unbiasedly to new information, that is, the market is efficient, \bar{u}_t can be viewed as an unbiased estimate of the market reaction to the information that came to the market in the t^{th} month from the date of accounting change. The expected values of both \bar{u}_t and U_t are zero and any significant deviations can be interpreted to be associated with the change in the accounting method.

Note that \bar{u}_t is an equally weighted average of price residuals for individual stocks. The relative effects of inventory changes on financial statements can differ considerably from one firm to another. Since information about the dollar effect of accounting changes was not available for most firms, the use of an equally weighted average seems to be the best recourse.

The purpose of examining the abnormal returns in the year preceding the accounting change is to detect the leakage of information to the market through channels other than financial statements. While it is known that the information about the accounting change is available to the market after the earnings announcement, it cannot be claimed that it had not become available earlier through other channels. Since the flow of information in these channels is hard to observe directly, it cannot be included in this model formally. This

failure leads to difficulties in the interpretation of results from this research design. These difficulties are discussed in Section 4 of this chapter.

Before the results from the application of this research design are presented, a few comments on a modified version of this model suggested by Ball (1972) seem appropriate.

AN ALTERNATIVE METHODOLOGY

Black (1972) has proposed a modification to the Sharpe-Lintner capital asset pricing model given by equation (2). Black does not assume that a riskless asset exists. His model, referred to as a "two-factor model" can be written as,

$$(9) \quad E(\tilde{R}_{jt}) = E(\tilde{R}_{zt}) + \lambda_{jt} (E(\tilde{R}_{mt}) - E(\tilde{R}_{zt}))$$

where R_{zt} is the return in period t on that minimum variance portfolio whose covariance with the market portfolio is zero. Other terms in (9) have the same definitions as in (2).

Ball uses the two-factor model to estimate \hat{u}_{jt} to study the relationship between several types of accounting changes and the behavior of stock prices. Since the validity of model (9) is still controversial, it is not a clearly preferred alternative to the single factor model (1) for the purpose of measurement in this thesis. Empirically, Black, Jensen and Scholes (1972) and Fama and McBeth (1972) provide some evidence that the data are not always compatible with model (1). But the compatibility of the data with the two-factor model has not been shown either. At the theoretical level, Stone (1972)

questions the validity of the derivation of the model (9) for two reasons: (a) market clearing conditions are not imposed and (b) more conditions are placed on the individual investor's personal equilibrium than the number of available variables. Stone also argues that the empirical results obtained by Black, Jensen and Scholes (1972) can be interpreted to reject the two-factor model. Blume and Friend (1973) "cast serious doubt on the validity of the market-line theory in either its original form or as recently modified." Until these issues are satisfactorily resolved, we have preferred to use model (1) for measurement in this study. In the next section, results from the application of the methodology described in this section to the data are presented.

3. RESULTS

Results from the application of the research methodology described in Section 2 to several subsets of the sample firms, are presented in this section. The interpretation of results is given in Section 4.

FIRMS CHANGING TO LIFO (GROUP A)

Average cumulative residual U_t for each of the 12 months before and after the date of change to LIFO is shown in Figure IV.1 and Table IV.1. Out of a possible 129, 119 firms are included in this analysis. Ten firms were dropped because the stock price data available for them on the C.R.S.P. File did not fulfil the minimum data requirements as specified in Section 2.

Table IV.1

ANALYSIS OF RESIDUALS IN 24 MONTHS SURROUNDING
THE DATE OF ACCOUNTING CHANGE TO LIFO

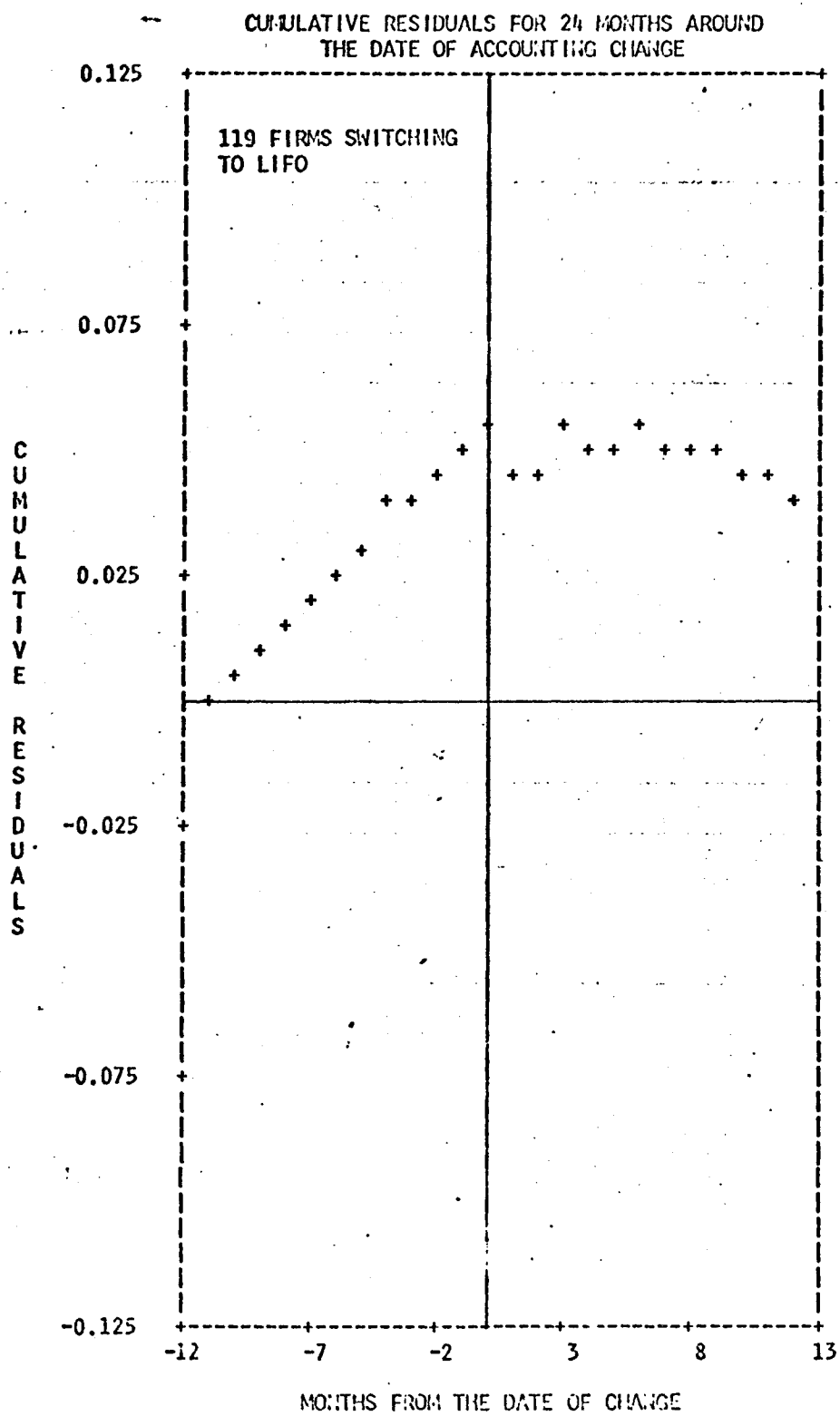
Group A

SAMPLE SIZE Month (1)	GROUP A ALL FIRMS 119		GROUP A WITHOUT STEEL FIRMS 97		STEEL FIRMS OF GROUP A ONLY 22	
	\bar{u}_t (2)	U_t (3)	\bar{u}_t (4)	U_t (5)	\bar{u}_t (6)	U_t (7)
-11	0.000	0.000	-0.003	-0.003	0.012	0.012
-10	0.005	0.005	0.008	0.005	-0.004	0.008
-9	0.006	0.011	0.006	0.010	0.009	0.017
-8	0.005	0.016	0.001	0.011	0.020	0.037
-7	0.002	0.019	0.003	0.014	0.001	0.038
-6	0.006	0.025	0.004	0.018	0.018	0.055
-5	0.007	0.032	-0.002	0.016	0.047	0.102
-4	0.007	0.039	0.003	0.019	0.023	0.126
-3	0.000	0.039	-0.003	0.015	0.017	0.142
-2	0.007	0.047	0.003	0.018	0.026	0.168
-1	0.006	0.052	0.004	0.022	0.013	0.181
0	0.001	0.053	0.000	0.023	0.004	0.185
1	-0.008	0.045	-0.010	0.012	0.000	0.186
2	-0.002	0.044	0.004	0.017	-0.027	0.159
3	0.011	0.055	0.011	0.027	0.014	0.173
4	-0.004	0.051	-0.002	0.025	-0.010	0.163
5	-0.001	0.051	0.001	0.027	-0.009	0.154
6	0.004	0.054	-0.001	0.026	0.024	0.178
7	-0.006	0.049	-0.008	0.018	0.003	0.181
8	0.001	0.050	0.000	0.018	0.008	0.188
9	0.001	0.051	0.001	0.019	0.001	0.189
10	-0.008	0.043	-0.011	0.008	0.006	0.195
11	-0.000	0.043	0.004	0.012	-0.018	0.177
12	-0.001	0.042	0.002	0.014	-0.015	0.161

\bar{u}_t is average residual; see equation (7) for definition

U_t is cumulative residual; see equation (8) for definition

Due to round off errors, average residuals may not sum to cumulative residuals



Group A

Figure IV.1

The average price of these stocks rose 5.3 % higher than the market index (after adjusting for relative risk) during the 12 months preceding the accounting change. Apparently, these stocks enjoyed exceptionally good times during this year. It is highly unlikely that this pattern of price increases could have occurred by random chance, since twelve consecutive residuals preceding the date of change are positive and the binomial probability of obtaining such a sequence of residuals is only about 0.00025. If the residuals are assumed to be normally distributed,⁴ the standard deviation of average cumulative price change for the 12 month period is 1.5 %. The observed price change of 5.3 % during the first 12 months is more than three standard deviations away from the expected price change (which is zero), and is, therefore, unlikely to have occurred by mere chance. It may be pointed out that no single residual during these 12 months is significantly different from zero.

During the year following the accounting change, the average abnormal price change was -1.3 %. This price change is within one standard deviation of the expected value zero. There seems to be no clear trend in the price changes of these stocks during this period.

In order to check on the homogeneity of Group A, that is, to

⁴Since actual stock return distributions have fatter tails than the normal distribution, the assumption of normality results in confidence intervals that are too narrow and the overstatement of the significance of these results. See Kaplan and Roll (1972) for details of the application of the stable symmetric distribution theory to this problem.

examine if the estimated residuals represent a general tendency of the firms in this group or an extreme behavior of a few firms, Group A was subdivided into five subgroups, A1, A2, A3, A4 and A5. After arranging all firms of Group A in order of increasing C.R.S.P. identification number, the first, sixth, eleventh etc. were assigned to Subgroup A1, second, seventh, twelfth etc. to Subgroup A2 and so on.⁵ Subgroups A1 through A4 had 24 firms each and A5 had 23.

Patterns of the average cumulative residuals U_t for each of these five subgroups are given in Figure IV.2. Patterns for all except one (A1) subgroups show strong similarity with the pattern obtained for Group A in Figure IV.1 in the sense that the average abnormal change in the price of these stocks was positive before the accounting change and about zero afterwards. This analysis supports the view that the results for Group A are fairly representative of a general tendency of firms in that group.

FIRMS CHANGING TO FIFO (GROUP B)

Twenty-two firms in Group B satisfied the minimum data requirements. The average and the average cumulative price changes for this group of stocks are given in Table IV.2 and the latter are also plotted in Figure IV.3. Compared to Figure IV.1, this pattern has more noise because the sample is smaller (22 in Group B versus 119 in Group A). During the 12 months preceding the date of accounting change, no

⁵ There is no a priori reason for a systematic bias in the results reported here due to this ordering procedure.

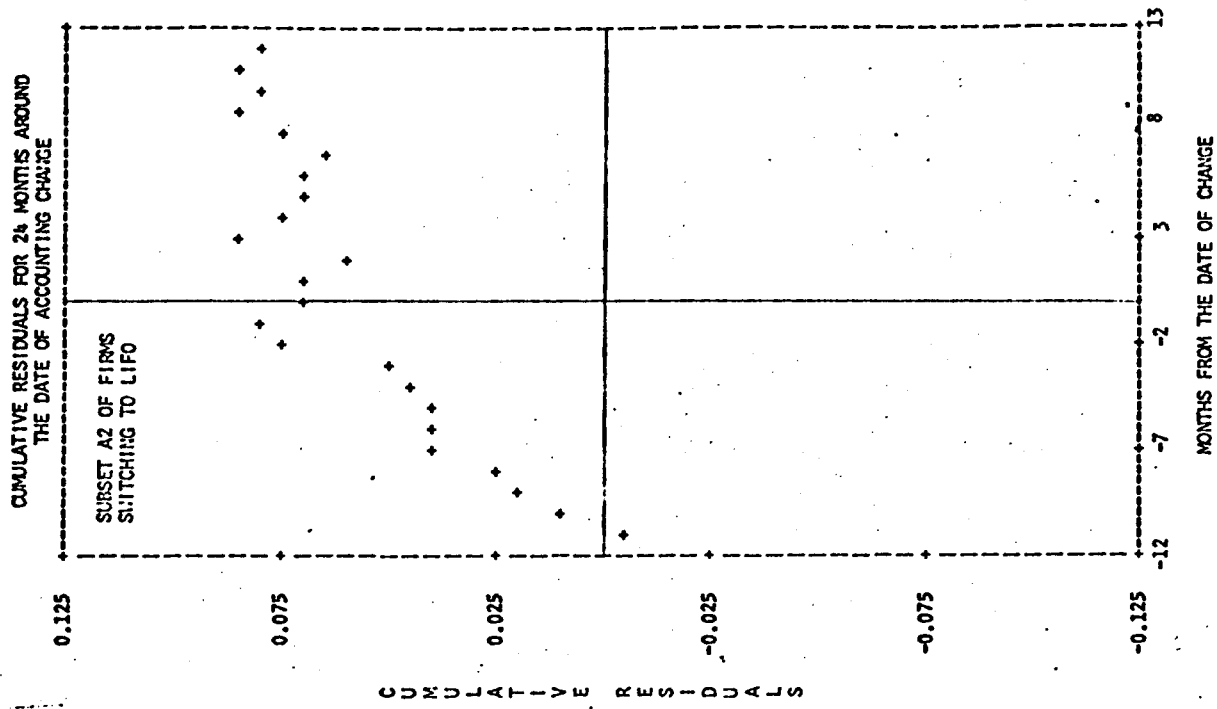


Figure IV.2b

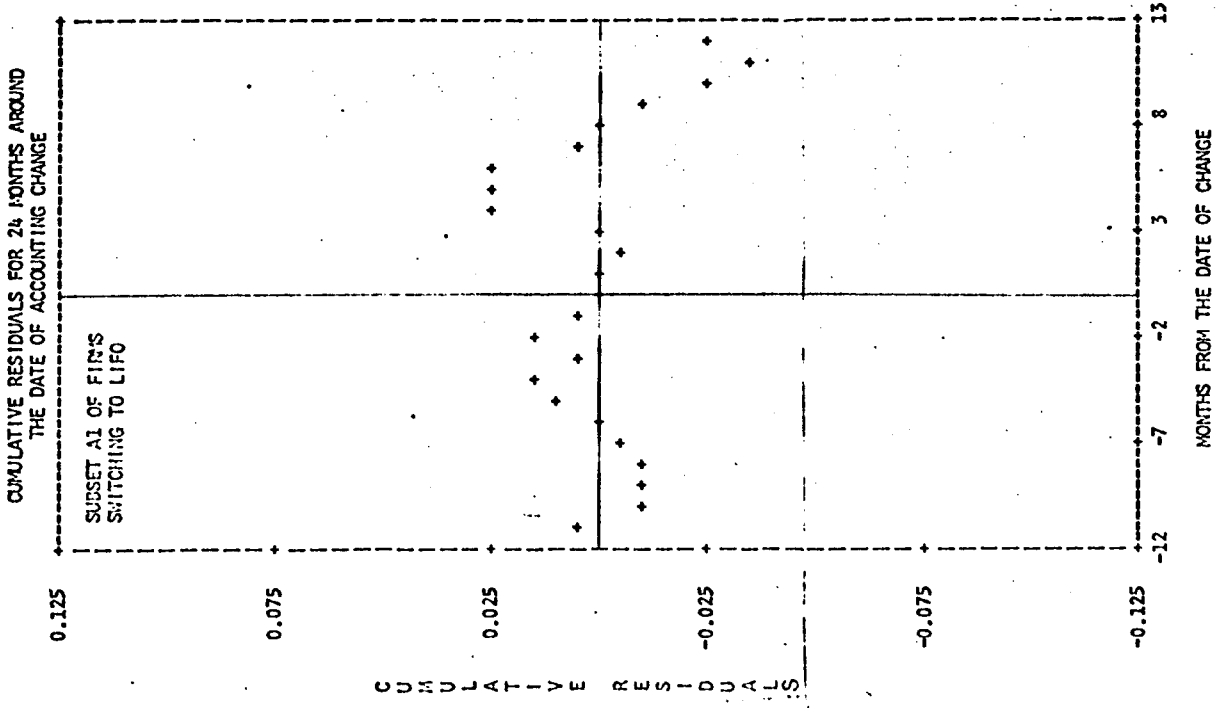


Figure IV.2a

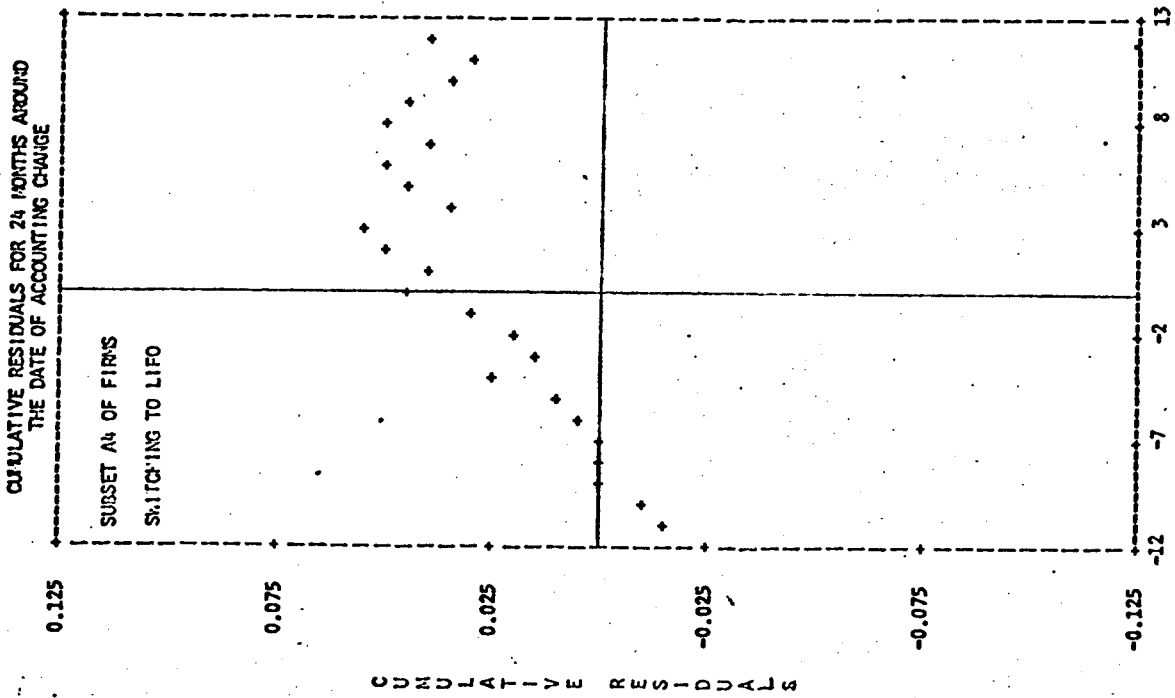


Figure IV.24

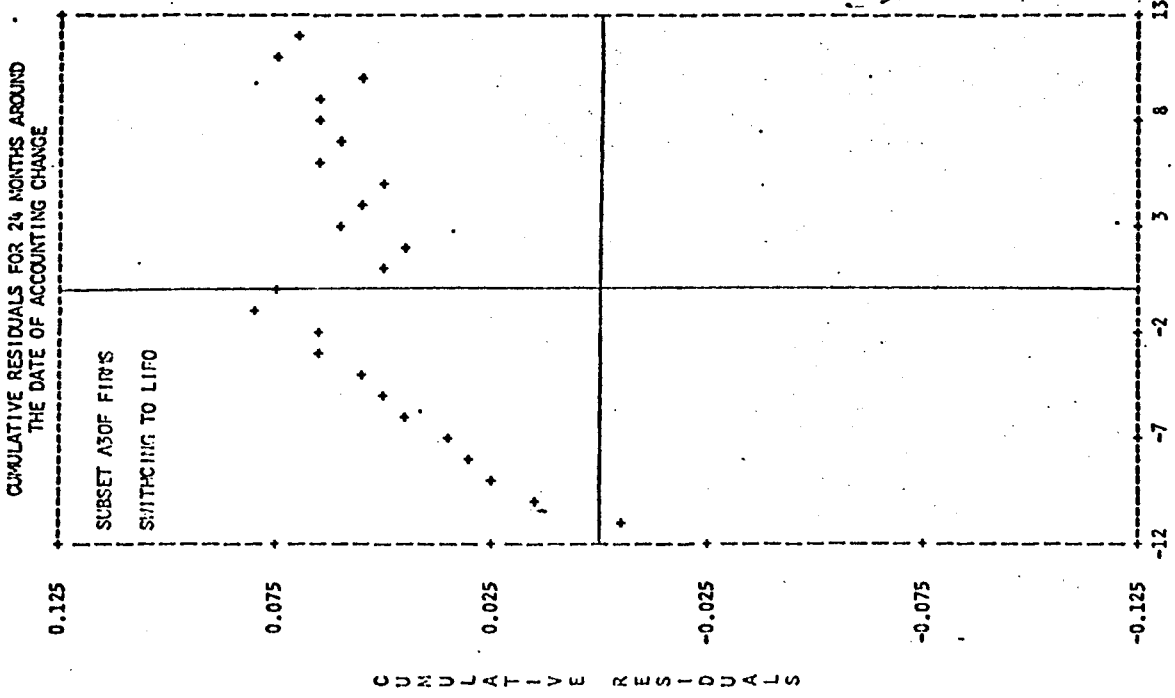


Figure IV.2c

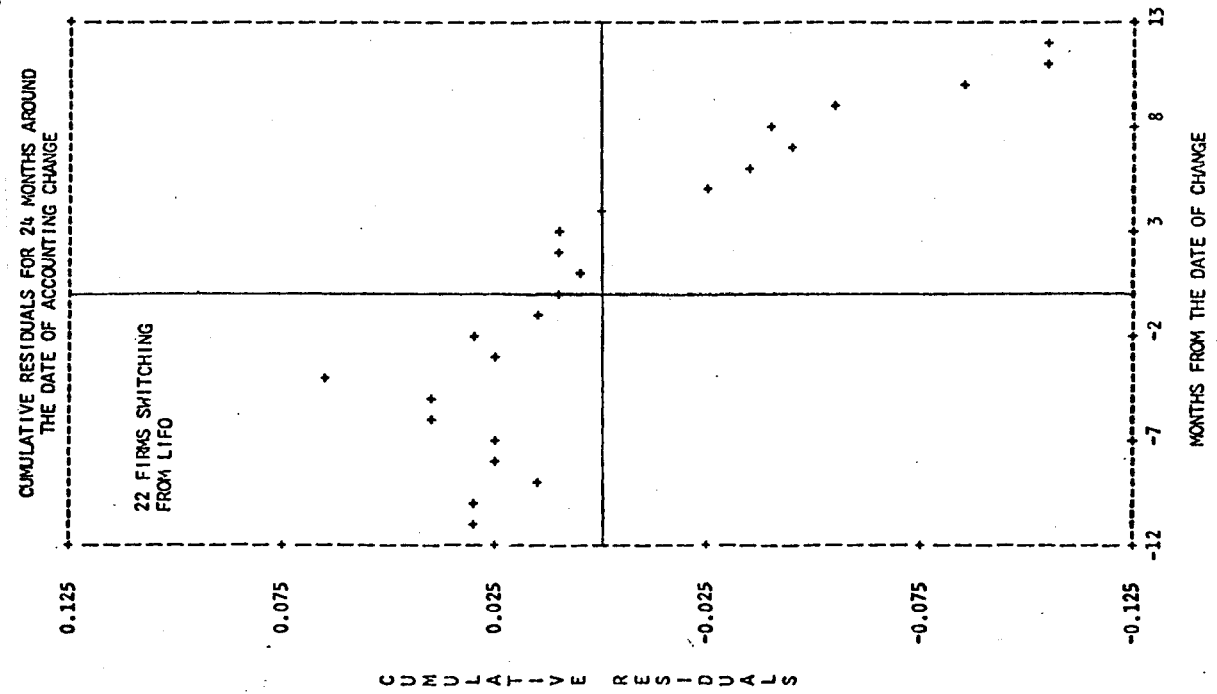


Figure IV.3
Group B

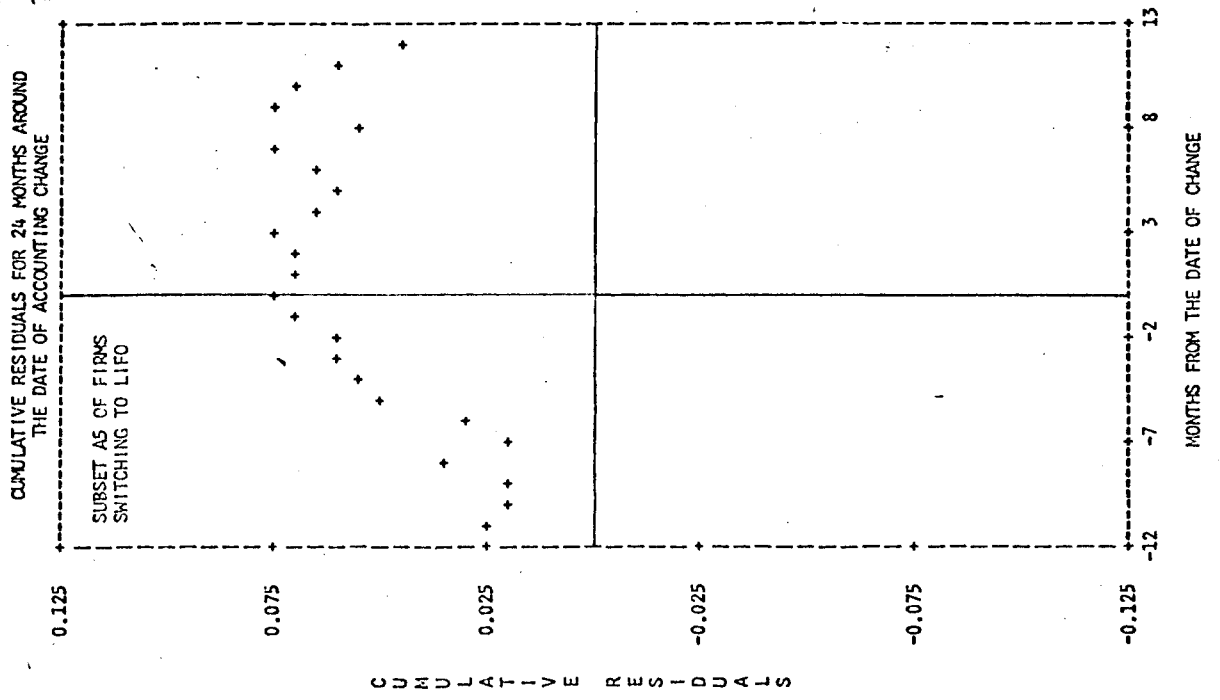


Figure IV.2e

Table IV.2

ANALYSIS OF RESIDUALS IN 24 MONTHS SURROUNDING
THE DATE OF ACCOUNTING CHANGE TO FIFO

Group B

SAMPLE SIZE Month	GROUP B ALL FIRMS 22		GROUP B WITHOUT TEXTILE INDUSTRY 17		GROUP B WITHOUT RETAIL INDUSTRY 17	
	\bar{u}_t	U_t	\bar{u}_t	U_t	\bar{u}_t	U_t
(1)	(2)	(3)	(4)	(5)	(6)	(7)
-11	0.028	0.028	0.029	0.029	0.026	0.026
-10	0.000	0.029	0.002	0.031	0.005	0.031
-9	-0.015	0.013	-0.010	0.021	-0.024	0.007
-8	0.012	0.025	-0.015	0.006	0.022	0.030
-7	0.000	0.026	0.003	0.008	0.001	0.030
-6	0.012	0.038	-0.008	0.001	0.022	0.052
-5	0.004	0.042	-0.017	-0.017	0.010	0.062
-4	0.024	0.066	0.003	-0.014	0.032	0.095
-3	-0.040	0.027	-0.013	-0.027	-0.051	0.044
-2	0.002	0.029	0.001	-0.026	0.006	0.050
-1	-0.014	0.015	-0.013	-0.038	-0.010	0.040
0	-0.007	0.008	-0.001	-0.040	-0.003	0.037
1	-0.003	0.005	-0.005	-0.044	-0.009	0.028
2	0.006	0.012	0.010	-0.034	0.012	0.039
3	-0.001	0.011	0.006	-0.028	-0.003	0.036
4	-0.009	0.002	0.001	-0.027	-0.012	0.024
5	-0.027	-0.025	-0.010	-0.037	-0.036	-0.012
6	-0.012	-0.037	-0.006	-0.042	-0.010	-0.022
7	-0.010	-0.047	-0.018	-0.061	-0.010	-0.032
8	0.008	-0.040	-0.002	-0.063	0.010	-0.022
9	-0.015	-0.055	-0.008	-0.071	-0.024	-0.046
10	-0.029	-0.084	0.011	-0.060	-0.029	-0.075
11	-0.023	-0.107	-0.009	-0.069	-0.029	-0.104
12	0.002	-0.106	0.019	-0.050	-0.006	-0.110

\bar{u}_t is average residual; see equation (7) for definition

U_t is cumulative residual; see equation (8) for definition

Due to round off errors, average residuals may not sum to cumulative residuals

consistent pattern of price changes can be observed. The average cumulative price change during this period is 0.8 % which is too small to be significant. During the 12 months following the accounting change, the price of these stocks dropped sharply by 11.4 %. Under the normality assumption (see footnote 4), the estimated standard deviation of the 12 month average cumulative price change is 5.9 %.

CONTROL GROUP C

Before drawing any conclusions from these results, it is useful to analyze the nature and extent of randomness in the average and cumulative residuals. A random sample of 120 stocks, called Group C hereafter, is drawn from the C.R.S.P. File.⁶ The stock price data of these stocks are analyzed by the same procedure as used above for Groups A and B. Average and average cumulative residuals for these 120 stocks for 24 months around a hypothetical date of accounting change are presented in Table IV.3. Cumulative residuals

⁶The following procedure was used to select this sample from the C.R.S.P. File:

- a. Look for the first stock for which at least 48 months of data are available. Include it in the sample.
- b. Skip three stocks.
- c. Stop if 120 stocks have been selected. Otherwise go to step a.

The middle point of the available time series for each stock included in this sample was taken to be the imaginary date of change for the purpose of this analysis. Names of these firms are listed in Appendix II.

For most firms of Groups A and B, end of the fiscal year and therefore the date of accounting change coincided with the end of the calendar year. This is not true for the control group. Since no predictable cyclical price movements are known to occur in the stock market, this discrepancy need not be of concern here.

Table IV.3

ANALYSIS OF RESIDUALS IN 24 MONTHS SURROUNDING A HYPOTHETICAL ACCOUNTING CHANGE FOR GROUP C

SAMPLE SIZE Month (1)	GROUP C 120		SUBGROUP C1 24 U_t (5)		SUBGROUP C2 24 U_t (7)		SUBGROUP C3 U_t^{24} (9)		SUBGROUP C4 U_t^{24} (11)		SUBGROUP C5 U_t^{24} (13)	
	\bar{u}_t (2)	u_t (3)	\bar{u}_t (4)	u_t (5)	\bar{u}_t (6)	u_t (7)	\bar{u}_t (8)	u_t (9)	\bar{u}_t (10)	u_t (11)	\bar{u}_t (12)	u_t (13)
-11	0.005	0.005	0.008	0.008	0.009	0.009	0.006	0.006	-0.010	-0.010	-0.006	-0.006
-10	0.009	0.014	0.023	0.031	-0.026	-0.017	0.003	0.009	-0.015	-0.025	0.012	0.006
-9	0.000	0.014	-0.004	0.027	0.004	-0.013	0.008	0.017	-0.024	-0.049	-0.002	0.004
-8	-0.008	0.006	-0.017	0.010	-0.012	-0.025	-0.034	-0.017	0.031	-0.019	0.032	0.036
-7	0.006	0.012	0.003	0.013	0.013	-0.012	-0.006	-0.023	0.001	-0.018	0.003	0.039
-6	-0.005	0.007	0.005	0.018	0.002	-0.010	-0.000	-0.023	-0.028	-0.046	0.000	0.039
-5	0.003	0.010	-0.001	0.017	0.008	-0.002	0.003	-0.020	0.001	-0.035	0.004	0.043
-4	0.008	0.018	0.010	0.027	-0.002	-0.004	0.002	-0.018	-0.011	-0.047	0.017	0.060
-3	-0.008	0.010	0.008	0.035	-0.004	-0.008	-0.034	-0.052	-0.021	-0.067	-0.014	-0.046
-2	-0.009	0.001	-0.007	0.028	-0.008	-0.016	-0.024	-0.076	-0.019	-0.086	0.003	0.049
-1	0.017	0.018	-0.012	0.016	-0.006	-0.022	0.079	0.003	-0.018	-0.014	0.016	0.065
0	0.005	0.023	0.019	0.035	-0.008	-0.030	-0.006	-0.003	-0.042	-0.146	0.005	0.070
1	-0.008	0.015	0.009	0.044	-0.018	-0.048	-0.022	0.025	0.002	-0.144	0.009	0.079
2	0.003	0.018	0.005	0.049	0.017	-0.031	0.009	-0.016	0.007	-0.137	0.002	0.081
3	-0.001	0.017	-0.007	0.042	0.003	-0.028	-0.010	-0.026	0.033	-0.104	0.017	0.098
4	0.003	0.020	-0.021	0.021	-0.000	-0.028	0.006	-0.020	-0.005	-0.110	0.027	0.125
5	0.008	0.028	0.001	0.022	0.000	-0.028	0.003	-0.017	-0.008	-0.117	0.022	0.147
6	0.000	0.028	-0.005	0.017	-0.014	-0.042	0.030	0.013	0.019	-0.098	-0.001	0.146
7	-0.009	0.019	-0.020	-0.003	-0.007	-0.049	-0.017	-0.004	-0.034	-0.132	0.014	0.160
8	-0.019	0.000	-0.014	-0.017	-0.012	-0.061	-0.022	-0.026	0.002	-0.130	-0.024	0.136
9	0.009	0.009	0.001	-0.016	0.000	-0.061	0.010	-0.016	0.012	-0.118	0.008	0.144
10	0.006	0.015	-0.001	-0.017	0.015	-0.046	0.005	-0.011	0.005	-0.113	0.002	0.146
11	-0.003	0.012	-0.020	-0.037	-0.010	-0.056	0.014	0.003	-0.011	-0.124	0.004	0.150
12	-0.002	0.010	-0.014	-0.050	0.010	-0.046	0.010	0.013	0.006	-0.118	-0.003	0.147

\bar{u}_t is average residual; see equation (7) for definition

U_t is cumulative residual; see equation (8) for definition

Due to round off errors, cumulative residuals may not be exactly equal to sum of average residuals

are also plotted in Figure IV.4.

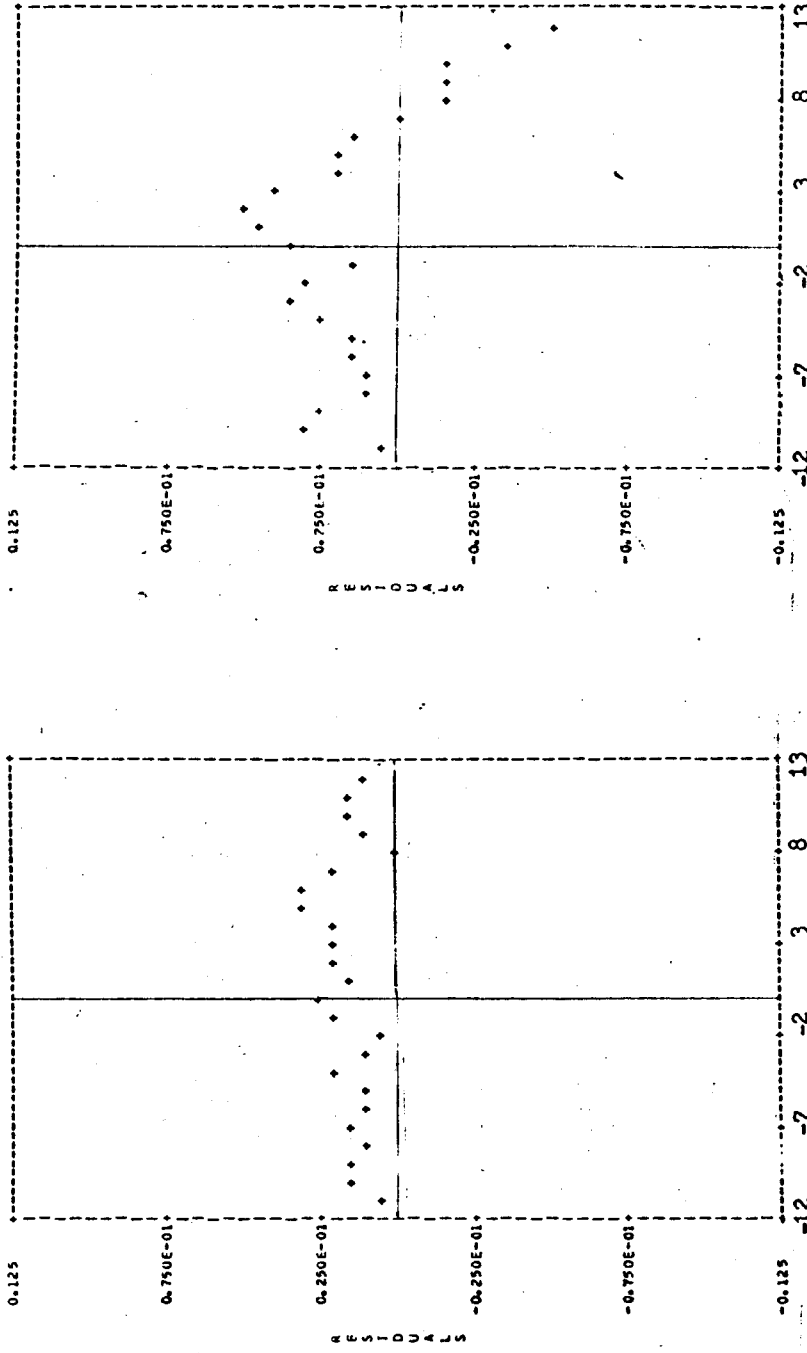
The pattern of cumulative residuals for Group C is in strong contrast to the pattern for Group A, though the two sample sizes are about same. During the 12 "pre-change" months, the average abnormal price change of stocks in Group C was only 2.3 % as compared to 5.3 % for Group A. During 12 months after the "change", the abnormal price change for Group C was -1.3 %.

To provide a standard of comparison for Group B and subgroups of A, Group C was divided into five subgroups, C1 through C5 of 24 stocks each by the same procedure as used for subdividing Group A. Patterns of the average cumulative residuals for these five subgroups are shown in Figures IV.5a through IV.5e. The average residuals and average cumulative residuals are presented in the last ten columns of Table IV.3. As expected, no dominant pattern of price changes is observed in these figures. Note that Figures IV.5a and IV.5d for random samples C1 and C4 are quite similar to Figures IV.2 for Group B. This result supports the view that (a) the pattern of residuals observed for Group B can be obtained for a random group of stocks and is not statistically significant, (b) the sample size of Group B and subgroups A1 through A5 is too small to yield useful results and (c) the difference in the pattern of results obtained for Subgroup A1 from other subgroups of A, need not be of much concern.

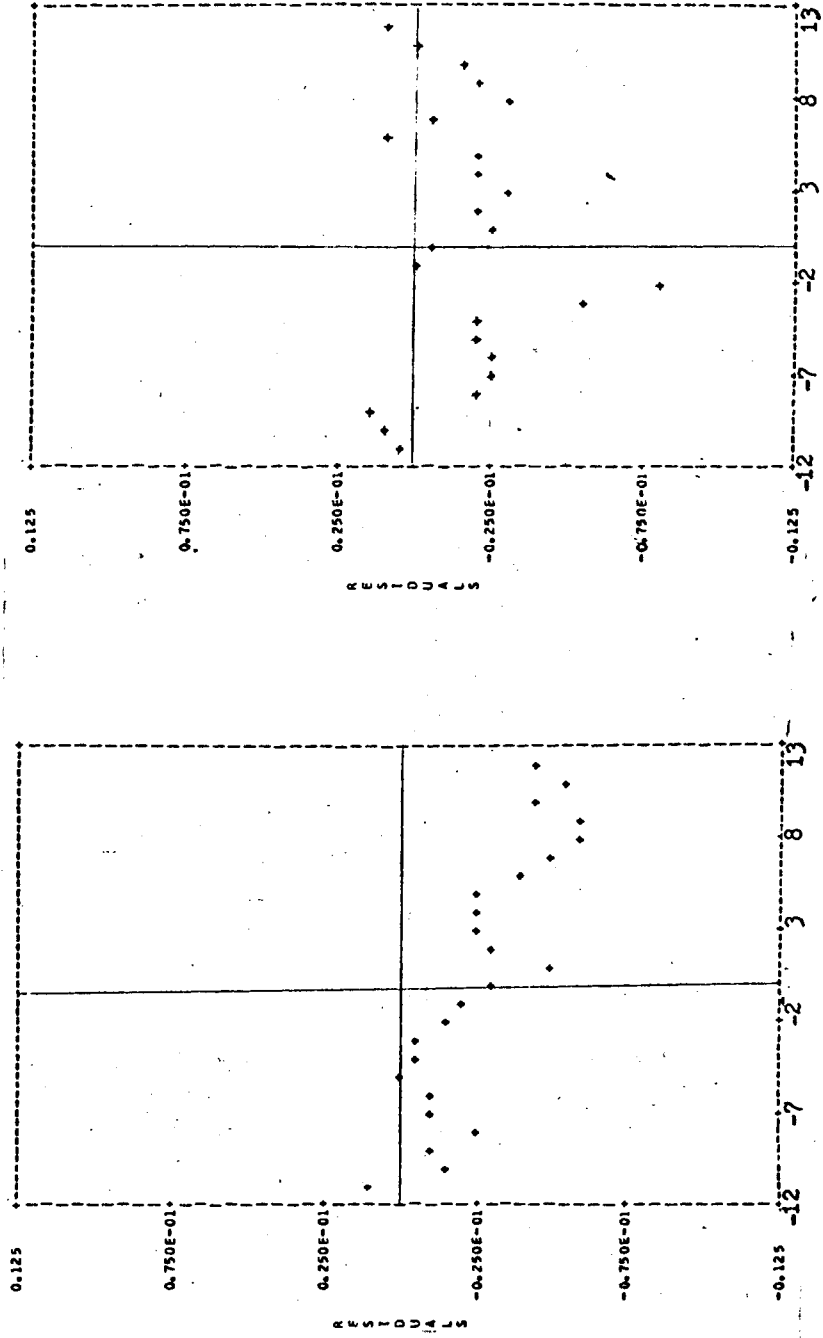
INDUSTRY EFFECTS

The analysis given above does not control for the industry effects. Since industry effects account for a relatively

CUMULATIVE RESIDUALS FOR 24 MONTHS AROUND THE DATE OF A HYPOTHETICAL ACCOUNTING CHANGE



CUMULATIVE RESIDUALS FOR 24 MONTHS AROUND THE DATE OF A HYPOTHETICAL ACCOUNTING CHANGE



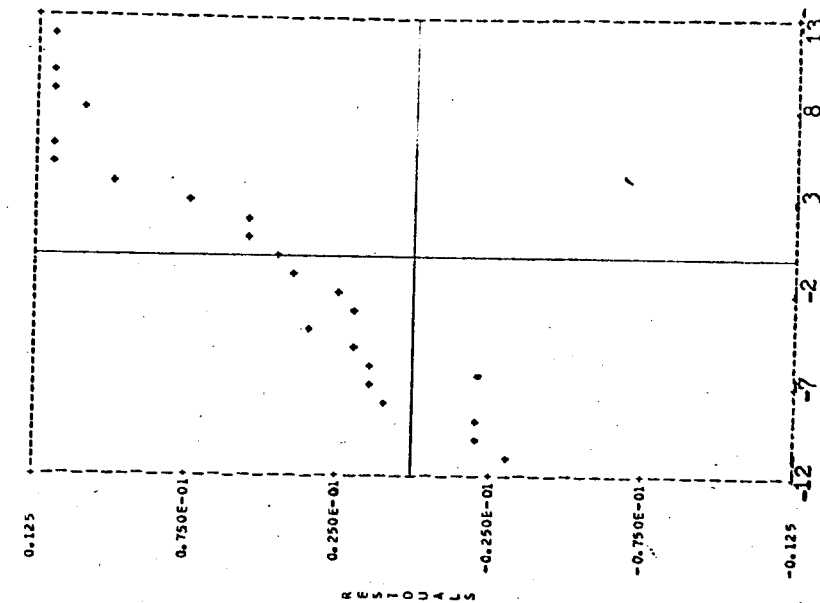
Group C2 (24 Firms)

Group C3 (24 Firms)

Figure IV.5b

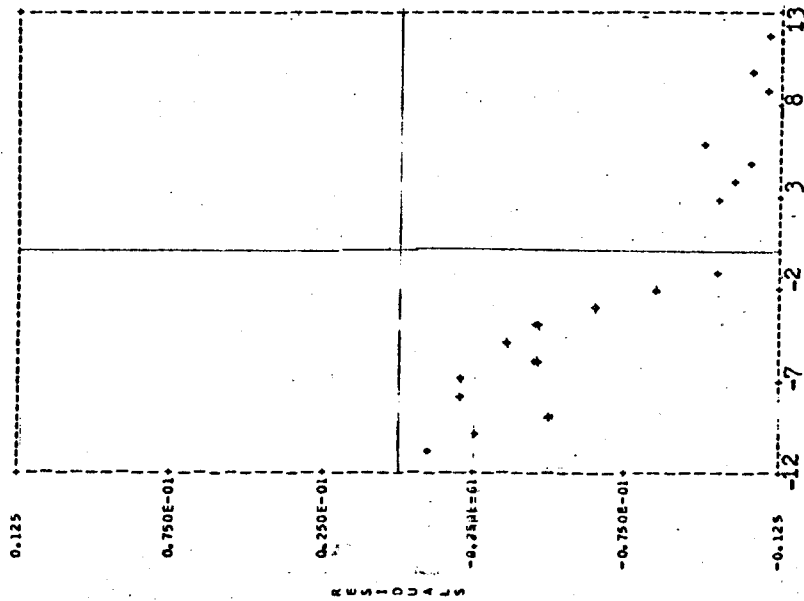
Figure IV.5c

CUMULATIVE RESIDUALS FOR 24 MONTHS AROUND THE DATE OF A HYPOTHETICAL ACCOUNTING CHANGE



Group C5 (24 Firms)

Figure IV.5e



Group C4 (24 Firms)

Figure IV.5d

small part of the rate of return variance,⁷ this would not be a serious problem if the industry-wise distribution of firms in the sample was more or less proportionate to the distribution of firms in the population.⁸ As can be seen from the Industry Profiles given in Appendix I.2, this is not the case. Eighteen percent of all firms in Group A are from the steel industry. Textile and retail store industries account for 27 and 19 percent respectively of all firms in Group B. These proportions are much higher than the share of these industries in the population. This calls for appropriate control of industry effects before the results are interpreted.

One approach to control for industry effects is to include a rate of return index for the appropriate industry as a second explanatory variable in the regression equation (5). Estimated residuals thus obtained would be orthogonal to both the market and the industry indices. This procedure would be acceptable if the accounting changes in a given industry did not occur simultaneously. If all or most firms in an industry make an accounting change at the same time, any relationship which may exist between the accounting change and stock price behavior will be included in the industry index and excluded from the estimated residuals. Since it is proposed to draw inference from this relationship on the basis of the estimated residuals, the inclusion

⁷King (1966) showed that the industry factor explains about 10 % of the variation of stock returns on average.

⁸The population of firms from which the sample is drawn is the intersection of the firms listed on the New York Stock Exchange and the firms surveyed by the American Institute of CPA's for reporting in Accounting Trends and Techniques.

of the industry indices in the regression is not likely to be of much help in the presence of industry wide accounting changes. Unfortunately in industries such as steel which are heavily represented in the sample, accounting changes were fairly widespread and simultaneous.

Alternatively, each sample can be analyzed by excluding one over-represented industry at a time. By comparing the results for such truncated samples with the results from the whole sample, an estimate of the importance of industry effect can be obtained. Columns 4 and 5 in Table IV.1 show the average and average cumulative residuals for 97 non-steel firms of Group A. The average price of non-steel stocks in Group A increased by 2.3 % during the 12 months immediately preceding the accounting change and decreased by 0.9 % during the following 12 months. A comparison of these numbers with the corresponding numbers for all stocks of Group A in columns 2 and 3 of Table IV.1 indicates that the tendency towards increase in price during the first 12 months is common to both steel and non-steel stocks, though it is considerably stronger in the former and weaker in the latter. A separate analysis of 22 steel stocks in Group A indicates that their prices rose by 18.6 % above the market during the first 12 months and fell by 2.5 % in the next 12 months.

The sample size of Group B, which was already quite small, was further reduced by the exclusion of over-represented industries. Results of analysis after excluding the textile and retail industries from the sample are given in Table IV.2 with the results for the whole

sample in columns 2 and 3.

4. INTERPRETATION OF RESULTS AND SUMMARY

GROUP A

The average stock price of the firms which switched to LIFO experienced a steady abnormal increase over and above the expected covariation of these stocks with the market factor during the year preceding the accounting change. This increase was unlikely to have occurred by random noise in a sample of this size. During the 12 months following the accounting change, prices remained about level with the market and there was no further distinguishable abnormal price change.

For reasons explained in Chapter III,⁵ the last date of the fiscal year during which the accounting change took effect, has been used as the date of accounting change. Thus month 0 in the tables and figures represents the last month of the fiscal year of accounting change. The observed price behavior of Group A can be given more than one interpretation:

(a) If it is held that information about the accounting change did not become available to the market before month 1, it can be inferred that the announcement of the accounting change, and associated tax deferment and understatement of earnings, did not have any "effect" on the market prices on average. No abnormal price trend is observable in the 12 months following the end of the fiscal year.

(b) Though no data are available on explicit public announcements of the firms' decisions to make the accounting changes to LIFO, it is possible that such decisions were taken sometime during the fiscal year and this information had leaked to the market. Abnormal price increase can thus be interpreted as the market's favorable response to the increase in the economic value of the firm arising from tax deferment. This interpretation supports Hypothesis 1 given in Chapter III.4. Since the decisions to change the accounting methods are more likely to be taken near the end of the fiscal year, more or less continuous price increase observed throughout the fiscal year cannot be completely explained by this interpretation.

(c) A third interpretation to the observed results can be given in terms of a selection bias in the sample of firms which changed to LIFO and in terms of the managements' motives to effect an accounting change. No attempt has been made in this study to examine the conditions and motives that may lie behind a management's decision to make a change in the method of inventory costing. Several studies have been made of the management's motives.⁹ Income smoothing, housecleaning, rationalization, diversification and decentralization are a few of the suggested motives. Moore (1972) has suggested that accounting changes may be associated with changes in management. If income smoothing is the motive, the management may decide to adopt LIFO at a time when earnings are increasing and to abandon it when earnings are decreasing.¹⁰ A housecleaning

⁹Cushing (1969), Gordon, Horwitz and Meyer (1966), Copeland (1968) and Gagnon (1967) are a few from a large body of literature.

¹⁰Since the Internal Revenue Service does not permit arbitrary changes in accounting for tax purposes, this policy instrument is not

motive will lead to the opposite policy.

It is possible that the increase in stock prices during the first 12 months occurred because of good business prospects for these firms, and an income smoothing motive led their managements to make a change to LIFO. Thus the association of the stock price increase with the accounting change may be spurious.¹¹ The improved earnings of the firms caused a rise in the stock price of the firm on the one hand, and caused the management to make the accounting change on the other because the management could "afford" to switch to LIFO in a period of high earnings. Therefore it is possible that Group A may contain a sample of firms biased towards the firms with better earnings prospects.

Probably the 5.3 % price increase observed here is caused partly by the tax effect (interpretation(b) above) and partly by the selection bias (interpretation (c) above). If more detailed data about the extent and effect of inventory changes were available, the tax effect on the value of the firm could be calculated and the remainder of the observed price increase could be attributed to the tendency of the management to change to LIFO during good times. Unfortunately, detailed data on the extent of inventory changes and its dollar effect

available for more than one application. However, in the sample of this study, ten firms did have reversals. It could not be ascertained from the available information if these reversals were effective for tax purposes.

¹¹See Simon (1954) for a discussion of spurious and true correlation.

on earnings etc. were not published by most firms in the sample. The quantitative effect of the accounting changes on the value of the firm can, however, be analyzed by a simple model in terms of four parameters --the marginal tax rate, expected rate of inflation, discount rate and the initial market value of LIFO inventory as a fraction of the market value of the firm's equity.

Let X_0 be the initial market value of the inventory at the beginning of the year in which LIFO is adopted. If I is the expected rate of inflation for all future years, the market value of this inventory at the end of year t will be:

$$X_t = X_0 (1 + I)^t$$

Therefore the increase in the market value of the inventory during year t will be:

$$X_t - X_{t-1} = X_0 ((1 + I)^t - (1 + I)^{t-1})$$

If physical inventory level were maintained at the initial level, the taxable income of the firm in year t will be higher by $(X_t - X_{t-1})$ under FIFO than under LIFO. If marginal tax rate for all future periods is T and the discount rate is K , present value P of all future tax savings by switching to LIFO will be:

$$P = \sum_{t=1}^{\infty} \frac{T (X_t - X_{t-1})}{(1 + K)^{t-1}} = T X_0 \sum_{t=1}^{\infty} \frac{(1 + I)^t - (1 + I)^{t-1}}{(1 + K)^{t-1}}$$

$$= T X_0 I (1 + K) / (K - I) \quad \text{for } K > I$$

If X_0 represents fraction F of the market value of the firm's equity E , the present value of the firm is increased by

$$(T \cdot F \cdot I (1 + K) / (K - I)) \cdot E$$

For a marginal tax rate of 50 % and when the value of LIFO inventory is one fifth of the market value of the equity ($F = 0.2$), the percent increase in the value of the firm for different values of I and K is given in the table below:

Expected Rate of Inflation I =	1 %	3 %	4 %
Discount Rate K = 5 %	2.6	16	42
10 %	1.2	4.8	6.8
15 %	0.8	2.8	4

It can be seen from the table that for values of inflation rate between 1 % and 4 % and for the discount rate in the range 5 % to 15 %, the increase in the value of firm associated with the accounting change varies between 42 % and .8%. Therefore it is difficult to estimate the expected price increase for the firms changing over to LIFO without prior knowledge of the parameters T, F, K and I for the firm. While a price increase of 5.3 % is in the feasible range, it cannot be claimed that all the observed increase was caused by the accounting change and none by the selection bias in the sample.

GROUP B

The results are difficult to interpret because it is very likely that they represent nothing more than noise. However, in the following paragraphs possible explanations of these results are offered on the same lines as given above for Group A.

- (a) Stock prices of these firms declined steeply during the nine-month period beginning three months after the accounting change. The reported earnings of these firms had increased as a

result of the accounting change and the accounting change had an adverse effect on the economic value of the firms. Therefore the price decline can be associated with the adverse economic effect of the accounting change. Since the price decline did not occur immediately after the accounting change, it could be inferred that it took several months for the investors to fully comprehend its effect and incorporate it into the prices. This interpretation supports Hypothesis 1.

(b) Since no definite trend in price behavior is visible during the pre-change 12 months, it could be inferred that the information about the accounting change did not leak out to the market in advance.

(c) Another explanation of the observed results is that the firms in this sample were not doing too well and their managements decided to boost the reported earnings through realization of inventory holding gains with the hope of being able to present a good image to the market. If this was the case, the attempt clearly failed because the market price of these firms declined sharply and progressively in the year following the accounting change. This interpretation of results implies that Group B has a downward bias in respect of the earnings prospects as compared to the population from which it has been drawn.

SUMMARY

Three different interpretations can be given to the observed increase in price of stocks of firms which changed their accounting method to LIFO. If the months preceding the accounting change are ignored, there is no association between LIFO and price changes. Some of the price increase observed in the months immediately preceding the end of the fiscal year might have occurred as a result of the increase in the economic value the firm due to tax deferral when decision to make the accounting change was taken. It is also possible that Group A is a biased sample of firms which had better than average earnings prospects. Such prospects led to anticipatory increase in the stock price on the one hand and a decision by the management to adopt LIFO due to income smoothing motives on the other.

Sharp decline in the price of Group B stocks following the accounting change suggests that it was caused by the adverse effect of the change. It is also possible that Group B is a biased sample of firms which had worse than average earnings prospects which led their managers to make an accounting change but the improved reported earnings failed to support the declining market price. However, it is very likely that the results for Group B represent little more than random noise due to smallness of the sample.

Results for both Groups A and B are consistent with Hypothesis 1 and are inconsistent with Hypothesis 2 as given in Chapter III.4. In other words, stock prices seem to follow the economic value of the firm rather than the reported earnings when changes in the economic value and reported earnings are in the opposite directions.

CHAPTER V

CHANGES IN ACCOUNTING AND RELATIVE RISK OF STOCKS (I)

1. INTRODUCTION

In Chapter IV, an attempt has been made to isolate the stock price changes associated with the accounting changes under study. It has been assumed while making this measurement that the relative risk of the stocks under study remained unchanged over the period from which data were used; or at least, there were no significant changes as far as this measurement is concerned. The objection to this methodology is that systematic risk of stocks may be a nonstationary parameter which changes with time. Ordinary least square estimates of this parameter used in Chapter IV may not be appropriate estimates. This would imply that the estimated residuals obtained from OLS regressions also might be inappropriate. In addition, the relative risk of firms may have a systematic relationship with the accounting changes. Whether such a relationship exists would have to be tested and its effects on estimated residuals examined.

There is little a priori reason or empirical evidence to support the view that systematic risk of stocks is sufficiently stable over time to justify the assumption that it is constant. In fact, some work done on this problem points to the possibility that it is not stable. A brief review of this literature and direct tests of a hypothesis about the general stability of the relative risk of stocks

are given in Chapter VI. In the remaining parts of this chapter it is assumed that the relative risk of stocks is constant in general, except for occasional discrete changes.

In Section 2 of this chapter, the possibility of association between accounting changes and changes in the relative risk of stocks is discussed. Stock price data of the firms which changed their accounting method for inventory costing are analyzed for changes in average relative risk before and after the accounting change in Section 3. The effect of these risk changes on estimated residuals and consequently, on the measurement of the relationship between stock prices and accounting changes, is presented in Section 4. Section 5 summarizes this chapter.

2. ASSOCIATION OF ACCOUNTING CHANGES WITH RELATIVE RISK CHANGES

According to the modern portfolio theory, the only characteristics of an asset which enter the decision model of an investor are its expected return and risk.¹ The market equilibrium conditions in the capital asset pricing model,² imply a linear relationship between the expected return of an asset and its risk relative to the portfolio. In equilibrium, a capital asset can be characterized by either one of these parameters--relative risk or expected return, and the other would be determined by the risk premium in the market. For the sake

¹Markowitz (1959)

²A brief description of the capital asset pricing model is given in Chapter IV.2. See Sharpe (1964), Lintner (1965) and Mossin (1966) for details.

of consistency (but without loss of generality), the remaining parts of the discussion in this section assume that the parameter in terms of which the capital market assesses a capital asset is its relative risk.

That the market assesses a capital asset on the basis of the information it receives is a truism. Changes in the market's assessment may occur due to either of the two reasons: (a) change in the economic status of the economic entity with respect to its environment and (b) changes in the information system relating the economic entity represented by the capital asset to the investors in the market. External accounting is commonly regarded as a part of this information system. Changes in the information system can, without any change in the associated economic situation, cause changes in the market's assessment of a capital asset. Ijiri, Jaedicke and Knight (1966) specified conditions under which decisions may change due to alteration in the information system which supplies the information. Beaver (1972) argued that each information system implies a set of equilibrium stock prices conditional upon the information system relating the business firms to the capital market.

It has been shown in Chapter III that an accounting change to or from LIFO changes the economic status of the firm. It has also been shown that the accounting numbers generated by different accounting methods are different. In the following paragraphs, the possibility of association between accounting and risk changes due to these two factors is discussed. The possibility of a risk change

caused by a change in the managerial decision process which might accompany the accounting switch is also discussed.

EFFECT OF LIFO ON RELATIVE RISK OF THE FIRM

A simple model of association between accounting changes to and from the LIFO method and changes in relative risk of the firm is presented here. The model is based on the economic impact of LIFO discussed earlier in Chapter III.

Let random variable \tilde{r}_m denote one period return on the market portfolio in the absence of unexpected inflation. Similarly, let random variable \tilde{r}_i be the one period return on the stock of firm i , which does not use LIFO, in the absence of unexpected inflation.

The effects of unexpected inflation on businesses have been a subject of controversy in the literature.³ These effects are ascribed to (a) the lag of costs and wages behind the price of the firm's products and (b) the debtor-creditor status of the firm. If wage changes lag behind price-level changes, unexpected inflation brings extra profits to business firms. The evidence on wage lag hypothesis from various empirical studies has not been conclusive. But it is generally accepted that wealth transfer from creditors to debtors takes place during unexpected inflation.

If business firms as a group have a debtor status, they would

³For a survey of wealth redistribution effects of inflation see Bronfenbrenner and Holzman (1963); for an analysis of the wealth redistribution effects of inflation, see Bach and Ando (1957); for the effects of inflation on business firms, see DeAlessi (1964); Nichols (1968) and Van Horne and Glassmire (1972).

stand to gain from unexpected inflation. If the wage lag hypothesis were true, they would gain even more from such inflation. Let \tilde{e}_m and \tilde{e}_i denote one period return due to unexpected inflation on the market portfolio and stock i respectively. According to the Sharpe-Lintner market equilibrium model which is formulated in nominal terms, the relative risk of firm i in the presence of unexpected inflation is defined by the ratio

$$(1) \quad \text{Cov} (\tilde{r}_m + \tilde{e}_m, \tilde{r}_i + \tilde{e}_i) / \text{Var} (\tilde{r}_m + \tilde{e}_m) = \beta_{iF}$$

Since $(\tilde{r}_i + \tilde{e}_i)$ is assumed to be the return of stock of firm i when it uses FIFO, β_{iF} is the risk of this firm under FIFO measured in terms of nominal variables.

It has been shown in Chapter III that in periods of inflation, firms which use LIFO earn additional return as compared to those firms which do not use this method. If firm i switches over to LIFO, it will earn an extra return in the presence of unexpected inflation. Denote this extra return by \tilde{l}_i . If the stock of the firm i constitutes only a small part of the market portfolio, its relative risk when it uses LIFO will be,

$$(2) \quad \text{Cov} (\tilde{r}_m + \tilde{e}_m, \tilde{r}_i + \tilde{e}_i + \tilde{l}_i) / \text{Var} (\tilde{r}_m + \tilde{e}_m) = \beta_{iL}$$

$$(3) \quad = \text{Cov} (\tilde{r}_m + \tilde{e}_m, \tilde{r}_i + \tilde{e}_i) / \text{Var} (\tilde{r}_m + \tilde{e}_m) \\ + \text{Cov} (\tilde{r}_m, \tilde{l}_i) / \text{Var} (\tilde{r}_m + \tilde{e}_m) \\ + \text{Cov} (\tilde{e}_m, \tilde{l}_i) / \text{Var} (\tilde{r}_m + \tilde{e}_m)$$

The change in relative risk of firm i when it switches to LIFO from FIFO is:

$$(4) \quad \beta_{iL} - \beta_{iF} = \text{Cov}(\tilde{r}_m, \tilde{l}_i) / \text{Var}(\tilde{r}_m + \tilde{e}_m) \\ + \text{Cov}(\tilde{e}_m, \tilde{l}_i) / \text{Var}(\tilde{r}_m + \tilde{e}_m)$$

Since the market return \tilde{r}_m in the absence of unexpected inflation and the extra return \tilde{l}_i on stock i due to unexpected inflation are uncorrelated, $\text{Cov}(\tilde{r}_m, \tilde{l}_i)$ is zero. $\text{Cov}(\tilde{e}_m, \tilde{l}_i)$ is positive, zero or negative depending on whether the change in market return due to unexpected inflation is positive, zero or negative. As discussed above, the existence of wage lag or debtor status of the firms in the market will lead to a positive change in return during unexpected inflation. The absence of wage lag and creditor status of the market firms will result in a negative value of $\text{Cov}(\tilde{e}_m, \tilde{l}_i)$.

Since

$$(5) \quad \beta_{iL} - \beta_{iF} = \text{Cov}(\tilde{e}_m, \tilde{l}_i) / \text{Var}(\tilde{r}_m + \tilde{e}_m)$$

the sign of the change in relative risk due to an accounting change to

LIFO will be the same as the sign of the covariance term.

Note that the above analysis uses the definition of risk given by the Sharpe-Lintner model which is formulated in nominal terms. The Sharpe-Lintner model does not explicitly consider the problem of unexpected inflation in obtaining the equilibrium conditions. Therefore in the presence of unexpected inflation, the equilibrium model and the definition of risk used above may be misspecified. Roll (1972) gives a detailed analysis of capital market equilibrium in the presence of unanticipated inflation.

DEBT EQUITY RATIO

As discussed in Chapter III.2, a change in the method of accounting for inventory may result in a change in the market price of the stocks of a firm. Empirical measurements in Chapter IV indicated that changes to the LIFO method were accompanied by an increase in the market value of the equity while the changes to the FIFO method were accompanied by a decrease in this value. Since the book value of debts and other liabilities specified in nominal terms, remain unchanged during inflation, accounting changes will result in a change in the debt equity ratio of the firm. The debt equity ratio will decrease for the firms which change to LIFO and increase for the firms which change to FIFO. Since the relative risk is a linear function of debt equity ratio, we should expect the relative risk of the firms changing to LIFO to decrease and to increase for the firms changing to FIFO.

SPECULATIVE INVENTORY POLICIES

It has been assumed so far that management policies remain unaffected by the accounting change. This assumption may not hold in certain circumstances. The LIFO method is usually applied to the year-end inventories. Since very low year-end inventories may lead to the loss of a low-priced LIFO base, realization of substantial inventory profits and creation of additional tax liability on these profits, firms with very old LIFO base may attempt to maintain level year-end inventories. In certain industries in which inventory prices are subject to seasonal or speculative changes, these accounting changes are almost certain to affect the inventory policies, primarily because of their tax implications. Such changes in the management policy may affect the riskiness of the firm, but the direction and extent of this effect are hard to specify from prior considerations alone.

3. MEASUREMENT OF CHANGES IN AVERAGE RELATIVE RISK

To measure changes in relative risk at the time of accounting changes, the relative risk of each stock in the sample is estimated before and after the accounting change. Twelve months of data from either side of the accounting change are excluded from these estimates because the expectation of abnormal residuals during this period is likely to bias the estimates. Pre-change estimates of the relative risk of each stock are made from OLS regression (6)

$$(6) \quad R_{jt} = \alpha_j + \beta_j R_{mt} + u_{jt} \quad (t = -71, \dots, -12)$$

where all terms are the same as defined earlier in Chapter IV and $t = 0$ is the month of the accounting change for the j^{th} firm. Up to 60 months of data are used in these regressions. Firms for which at least 24 months of data are not available, are excluded from the analysis. Summary statistics of these estimates for each group are given in Table V.1 under the column heading Regression 2. Corresponding summary statistics from estimates computed in Chapter IV from pooled data before and after the accounting change are given under heading Regression 1.

A similar set of estimates of relative risk is made from 60 months of post-change data, that is ($12 < t \leq 72$) is the range of data used. Summary statistics for this set of estimates are given under Regression 3 in Table V.1. The last part of this table shows the differences between pre- and post-change estimates. Since only those firms are included in this analysis for which at least 24 months of data were available for both regression sets 2 and 3, the sample size is reduced to 115 for Group A and 14 for Group B. Control group C comprises 120 firms "randomly" selected from the C.R.S.P. tape. A description of this selection procedure is given in Chapter IV.3.

Table V.1 indicates that the cross sectional mean of the relative risk of Group A firms (which made an accounting change to LIFO) increased by 0.102 between pre-change and post-change periods. The t-statistic of this change is 4.1 which is quite significant.⁴ The cross sectional median of the relative risk of

⁴Though this statistic is being called a t-statistic because it is a ratio of an estimate to its estimated standard error, it may not have a Student-t distribution, and a measure of care is called for

Table V.1

Changes in Risk Coefficients after the Accounting Change

	Regression 1 ^a		Regression 2 ^b		Regression 3 ^c		Difference between regressions 2 and 3							
	$\bar{\beta}$	$\hat{\sigma}_{\beta}$	$\hat{\beta}_m$	$\bar{\beta}$	$\hat{\sigma}_{\beta}$	$\hat{\beta}_m$	$\Delta\bar{\beta}$	$\hat{\sigma}_{\Delta\bar{\beta}}$	T	$\Delta\hat{\beta}_m$	$(\Delta\hat{\beta})_m$			
Group A	1.030	.0017	1.05	1.012	.015	0.99	1.114	.020	1.12	+1.02	.025	4.1	+1.13	+1.11
Group B	.901	.0385	.865	.971	.0518	.965	.839	.0615	.75	-.132	.0804	-1.64	-.215	-.045
'Control' Group C	.987	.019	.99	.959	.034	.92	.99	.026	.93	+0.03	.043	0.7	+0.01	-.01

12 months on either side of change excluded from all regressions

- a Regression 1. Using 120 months of data (60 months on either side of change date)
- b Regression 2. Using 60 months of data before the change
- c Regression 3. Using 60 months of data after the change

$\bar{\beta}$ = cross sectional mean of individually estimated $\hat{\beta}$

$$\hat{\sigma}_{\beta} = \frac{1}{N} \left\{ \sum_{\text{Group A or B}} (\hat{\sigma}_{\beta_j}^2) \right\}^{1/2}, \quad N = \text{number of companies in the group}$$

$\hat{\beta}_m$ = median of individually estimated $\hat{\beta}$

$$\Delta\bar{\beta} = (\bar{\beta})_2 - (\bar{\beta})_1$$

$$\hat{\sigma}_{\Delta\bar{\beta}} = \hat{\sigma}_{\beta_1}^2 + \hat{\sigma}_{\beta_2}^2$$

$$T = \Delta\bar{\beta} / \hat{\sigma}_{\Delta\bar{\beta}}$$

$$\Delta\hat{\beta}_m = (\hat{\beta}_m)_2 - (\hat{\beta}_m)_1 = \text{change in median of } \hat{\beta}$$

$(\Delta\hat{\beta})_m$ = median of changes in risk coefficients of individual stocks

Group A firms also increased by a comparable amount of 0.13. The cross sectional median of changes in the relative risk of individual firms between these periods was 0.11. These order statistics support the view that the observed increase in the average relative risk of Group A firms represents a general tendency of the sample and is not caused by a few large changes.

For Group B firms (which made an accounting change to FIFO), changes in the cross sectional mean and median of estimated relative risk were -0.132 and -0.215 respectively. The t-statistic of mean change was -1.64. Though this change is less significant than the change for Group A firms, it is worth noting that the risk of these firms decreased after the accounting change. The median of changes in the relative risk of individual firms was -0.045. For Group B, as for Group A, order statistics confirm that the changes in mean reflect the general tendencies of the respective samples.

The summary statistics for control Group C are strikingly different from those for Groups A and B. Even though the sample size of Group C is comparable to the sample size of Group A, the average change in the risk of these firms is only 0.03 with a t-statistic of 0.7. The change in cross sectional median is +0.01 and the cross sectional median of changes in the relative risk of individual firms is -0.01.

in its interpretation for two reasons: (a) stock price returns are believed to have non-gaussian fat-tailed distributions; the ratio of estimated coefficient to its standard error of estimation in linear model has a Student-t distribution only when the error terms are gaussian, (b) standard error of estimation is biased downwards when coefficients are not stationary. If the risk coefficient is changing, as has been suggested in this chapter and tested in Chapter VI, the t-estimate is biased away from zero. See Rosenberg (1968, Chapter 4)

The lack of significance of these changes leads further support to the view that the changes to and from LIFO were accompanied by changes in the relative risk of the firms in Groups A and B.

Table V.2 shows the results of the application of χ^2 -test on the pre- and post-change distributions of estimated relative risk of Group A firms. χ^2 statistic with 11 degrees of freedom is 23.8. Since $\chi^2_{11,0.95} = 19.67$ and $\chi^2_{11,0.99} = 24.72$, there appears to be a significant shift to the right in the distribution of the relative risk of firms in this group. There is less than a 5 % chance that χ^2 statistic could be so large when in fact, there was no difference in the distribution of the two populations. Though about one half of the magnitude of this χ^2 statistic arises from the last of the 12 intervals in Table V.2, it is noteworthy that the frequency changes on each of the first 6 intervals are non-positive followed by non-negative frequency changes in each of the last 6 intervals. This observation further supports the inference of a rightward shift in the distribution of the relative risk. The sample size of Group B is too small to conduct a similar test of significance on the changes in relative risk.

4. EFFECT OF CHANGES IN RELATIVE RISK ON MEASUREMENT OF ABNORMAL PRICE CHANGES

The tests conducted in Section 3 create a reasonable doubt about the appropriateness of the assumption that accounting changes under study are not accompanied by changes in relative risk. The research design used in Chapter IV does not consider the possibility of such changes. The

Table V.2

Comparison of Distribution of Risk Coefficients before and after the Accounting Change

Group A

$\hat{\beta}$ Range (less than)	.51	.65	.75	.86	.95	1.01	1.09	1.17	1.28	1.39	1.58	2.27	Total
f_1 Frequency before Change-Regression 2	10	10	10	10	10	10	10	10	10	10	10	5	115
f_2 Frequency after Change-Regression 3	10	6	5	6	7	7	13	13	11	10	14	13	115
$f_2 - f_1$ Difference in Frequencies	0	-4	-5	-4	-3	-3	+3	+3	+1	0	+4	+8	0

$$\Sigma \frac{(f_2 - f_1)^2}{f_1} = 23.8$$

effect of ignoring the risk changes on measurement of abnormal price change is analyzed in this section. It is shown that the measured abnormal price changes can be quite misleading if the ignored changes in relative risk are large enough.

Let β_{j1} and β_{j2} be the relative risk of a firm before and after the change to LIFO respectively. Let $\hat{\beta}_j$ be the ordinary least square estimate of the risk coefficient from T observations before plus T observations after the accounting change. The market model can be written as,

$$(6) \quad R_{jt} = \alpha_j + \beta_j R_{mt} + u_{jt} \quad (t = -T+1, \dots, T)$$

where

$$\beta_j = \begin{cases} \beta_{j1} & \text{for } t \leq 0 \\ \beta_{j2} & \text{for } t > 0 \end{cases}$$

The expected value of estimate $\hat{\beta}_j$ lies between β_{j1} and β_{j2} . Abnormal price changes or residuals are estimated from the equation,

$$(7) \quad \hat{u}_{jt} = R_{jt} - \hat{\alpha}_j - \hat{\beta}_j R_{mt}$$

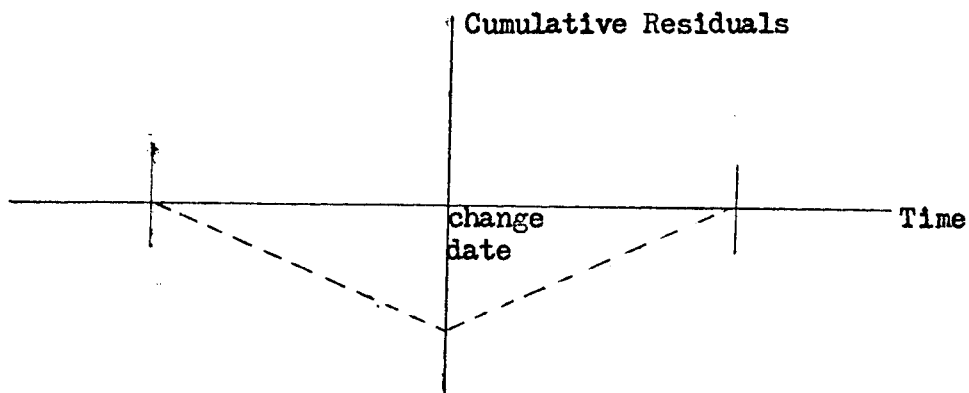
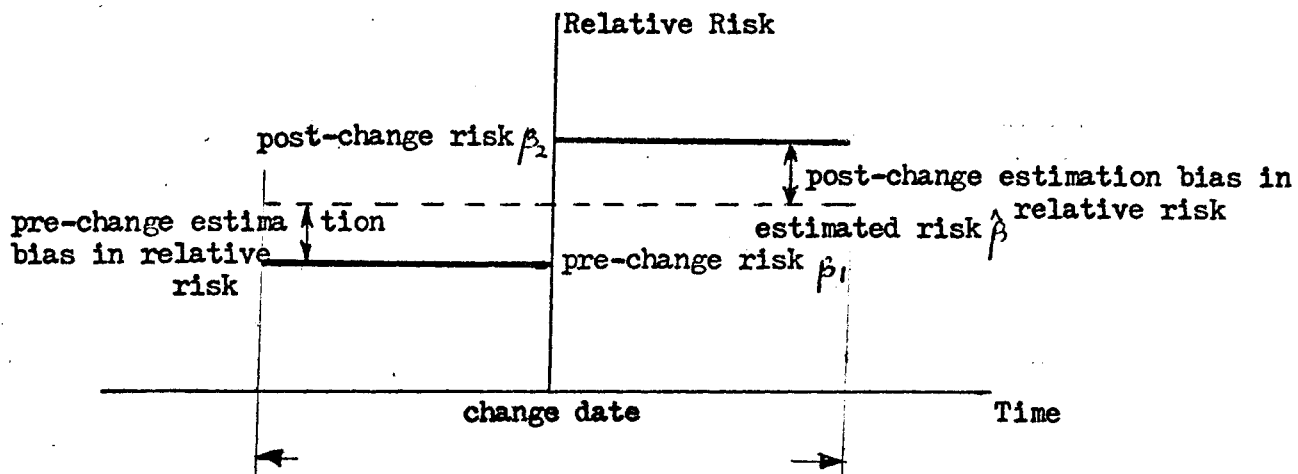
Since estimated risk $\hat{\beta}_j$ is not an unbiased estimate of the relative risk of the firm either before the accounting change or after, the estimated residuals \hat{u}_{jt} are also biased.

$$(8) \quad E(\hat{u}_{jt}) = \begin{cases} R_{mt} (\beta_{j1} - E\hat{\beta}_j) & \text{for } t \leq 0 \\ R_{mt} (\beta_{j2} - E\hat{\beta}_j) & \text{for } t > 0 \end{cases}$$

The expected value of the estimated residuals is non-zero for non-zero

Figure V.1

Estimation Bias in Relative Risk and Residuals when Accounting
Change is Accompanied by a Change in Relative Risk



values of the market factor R_{mt} . When R_{mt} is positive, the pre-change residuals are positively biased if $\beta_{j1} > \beta_{j2}$, and negatively biased if $\beta_{j1} < \beta_{j2}$. The opposite is true for the post-change residuals. Since the mean value of the market factor R_{mt} is positive, the above statements about the residual bias for the positive values of R_{mt} are also true for all values of R_{mt} on average. If an accounting change is accompanied by a discrete change in the relative risk, and if no abnormal residuals actually exist, data analysis by the research design given in Chapter IV will result in a pattern of cumulative residuals shown in Figure V.1

Some serious deficiencies of the methodology employed in Chapter IV can now be pointed out:

- (a) Such analysis may indicate abnormal price changes when in fact none exist.
- (b) Even when abnormal price changes exist, this analysis may fail to detect such changes due to the presence of changes in relative risk.
- (c) In the presence of risk changes, estimated abnormal returns on stocks are dependent on the section of time series data used to estimate the risk coefficient. To the extent that this choice is made arbitrarily, the estimated abnormal performance also is arbitrary. The extent of changes in the abnormal performance measured in Chapter IV, due to the arbitrary selection of time series is shown in the following

analysis.

Cumulative residuals estimated from three different sets of regressions for Groups A and B are shown in Table V.3. Rows a, b and c of the table give the cumulative residuals estimated from pooled, pre-change and post-change regression estimates respectively. Starting 12 months before the accounting change, columns two and three show the cumulative residuals at the month of change and 12 months after this date respectively. The average abnormal price change for Group A stocks during the 12 months immediately preceding the accounting change is 5.3 % from the pooled regression estimates. This changes to 7.5 % if the pre-change estimates of relative risk are used and to 3.3 % if the post-change estimates are used. Estimates of abnormal price change during the two year period ending the 12 months after the accounting change also show similar dependence on the choice of data from which the relative risk is estimated. The second part of the table for Group B also shows heavy dependence of cumulative residuals on the choice of the regression set.

It can be argued that in the presence of risk changes, the abnormal performance should be measured by using pre-change estimates of risk for pre-change residuals and post-change estimates for post-change residuals. Cumulative residuals computed by this method are given in row d of Table V.3 for both the groups. For Group A stocks, there was an abnormal price increase of 7.5 % during the 12 months immediately preceding the accounting change followed by a decline of 2.3 % during the next 12 months. For Group B stocks, a 0.5 % abnormal

Table V.3

Cumulative Residuals Using Different Estimates of Risk

		12 months before change	0 months before change	12 months after change
Group A	a	0.00	0.053	0.042
	b	0.00	0.075	0.082
	c	0.00	0.033	0.010
	d	0.00	0.075	0.052
Group B	a	0.00	0.008	-0.105
	b	0.00	-.005	-.147
	c	0.00	.025	.038
	d	0.00	-.005	.008

- (a) pooled estimates of risk
- (b) pre-change risk estimates
- (c) post-change risk estimates
- (d) pre-change estimate used for pre-change residuals
and post-change estimate used for post-change residuals.

decline in prices during the 12 pre-change months was followed by a 1.3 % rise in the 12 post-change months on average.

One of these four sets of cumulative residuals for each group is appropriate for drawing inference about the relationship between accounting changes and stock prices under different assumptions about the behavior of systematic risk. To find which of these assumptions is right, it is desirable to estimate the time path of the relative risk of firms in the sample. Ball (1972) attempts to do so by using ordinary least square regression over 101 months of data around the date of accounting change. It has been shown that OLS estimates are not optimal (in the minimum variance sense) estimates when coefficients are subject to change.⁵ Ball's assertion that any change in the relative risk is likely to be towards unity is contradicted by the behavior of his sample in the post-change period. In the next three chapters of this study, an alternative method of testing and accounting for risk changes is presented and applied.

5. SUMMARY

The research design used in Chapter IV to study the relationship between accounting changes (sometimes referred to as the API analysis) and stock price behavior can be questioned on the grounds that the relative risk of firms is constant over time. There is no prior reason for this assumption. Measurements of average risk during the five years immediately preceding and following the accounting change

⁵See Rosenberg (1968) and Fisher (1971)

indicate that systematic changes in relative risk might be associated with accounting changes. The relative risk of firms which adopted LIFO seems to have increased after this change. The relative risk of firms which abandoned the use of LIFO decreased in the post-change period.

The estimates of abnormal price changes (defined in Chapter IV) are sensitive to the changes in the estimates of relative risk. If the estimates of relative risk are different over different parts of the time series, the researcher is required to make an additional assumption about the part of the time series that should be used for the purpose of estimation. In the next chapter, the problem of testing for changes in risk is examined and better methods for doing so are proposed and applied. In the subsequent chapters, new methods of accounting for risk changes in studying the relationship between stock prices and various economic events are presented and used for inference.

CHAPTER VI

STATISTICAL TESTING OF CHANGES IN RELATIVE RISK OF STOCKS

1. INTRODUCTION

In the previous chapter, it had been assumed that the relative risk of a stock remains unchanged except for an occasional shift which may accompany certain economic or accounting events. This assumption was used to justify the use of ordinary least square estimates of risk during pre- and post-accounting change periods in order to test if changes in relative risk are associated with the accounting events. In this chapter, the problem of testing whether the relative risk of firms is a constant or a changing parameter is analyzed in a more general framework. Models which may provide suitable description of the relative risk process over time are presented, and statistical tests are proposed to draw inference about the descriptive validity of these models for stock price behavior. After conducting tests on stock price data it is inferred that the constant relative risk model used in previous chapters does not have descriptive validity. In Chapter VII, estimation procedures which have been shown to be optimal in a changing risk environment are presented and applied to the data to draw inference about the relationship between changes in accounting and changes in the price and risk of stocks.

2. MODELS OF RISK CHANGES

Market model (1) discussed in the previous chapters is a simple

linear model with an additive disturbance term.

$$(1) \quad R_t = \alpha + \beta R_{mt} + u_t \quad (t = 1, \dots, T)$$

In the familiar notation of general linear models where x_t and y_t are the observations on the independent and dependent variable respectively in period t , this model is rewritten as:

$$(2) \quad y_t = \beta_1 + \beta_2 x_t + \varepsilon_t \quad (t = 1, \dots, T)$$

where x_t is nonstochastic, t is the time subscript and

$$E(\varepsilon_t) = 0$$

$$E(\varepsilon_t \varepsilon_s) = \begin{cases} 0 & \text{for } t \neq s \\ \sigma_\varepsilon^2 & \text{for } t = s \end{cases}$$

The problem of testing for changes in the relative risk of a stock as defined by parameter β of the market model (1) is identical to the problem of testing for changes in slope β_2 in the linear model (2). Statistical tests for several different kinds of slope changes have been discussed in the literature.

Chow (1960) proposes a test¹ for detecting a single change in slope β_2 at a known point t^* in time series.

$$(3) \quad y_t = \beta_1 + \beta_2 x_t + \varepsilon_t \quad (t = 1, 2, \dots, T)$$

where

$$\beta_2 = \begin{cases} \beta_2' & \text{for } t = 1, 2, \dots, t^* \\ \beta_2'' & \text{for } t = t^* + 1, \dots, T \end{cases}$$

¹Chow's procedure is applicable to multiple regression models.

In other words, the time series has slope β_2' for the first t^* observations and β_2'' for the last $(T-t^*)$ observations.

Chow proposes a procedure for testing the hypothesis ($\beta_2' = \beta_2''$) against the alternative hypothesis ($\beta_2' \neq \beta_2''$). Quite often, the point in time series when shift might have occurred is unknown and is itself a purpose of investigation. Farley and Hinich (1970) and Farley, Hinich and McGuire (1971) propose tests for detecting a single slope change without any prior knowledge about the location of such a shift in the time series. These procedures are applicable to the slope change model given in (3) if t^* is assumed to be unknown and can be estimated.

Model (3) can be characterized as a single discrete slope change model. Another relevant class of structural changes is characterized in the literature as random coefficient models, in which the coefficients are postulated to be random variables with known or unknown distributions. Consider model:

$$(4) \quad y_t = \beta_{1t} + \beta_{2t} x_t + \epsilon_t \quad (t = 1, \dots, T)$$

where x_t is a nonstochastic independent variable, coefficients β_{1t} and β_{2t} are random variables with constant means and variances, disturbance term ϵ_t is identically and independently distributed, t is the time subscript and T is the total number of observations.

Since randomness of the intercept term β_{1t} is unidentifiable from the disturbance term ϵ_t , the two can be combined together without loss of generality. Therefore the random coefficient model can be written as:

$$(5) \quad y_t = \beta_{1t} + \beta_{2t} x_t \quad (t = 1, \dots, T)$$

where

$$E(\beta_{1t}) = \beta_1$$

$$E(\beta_{2t}) = \beta_2$$

In the framework of the random coefficient model, several different sets of assumptions can be made about the randomness of parameters β_{1t} and β_{2t} . One specification is:

(5a) β_{1t} and β_{2t} are random variables with constant means and variances and are distributed independently of each other and of themselves, i.e.

$$E(\beta_{1t}) = \beta_1$$

$$E(\beta_{2t}) = \beta_2$$

$$\text{Cov}(\beta_{1t}, \beta_{1s}) = \begin{cases} 0 & \text{for } t \neq s \\ \alpha_1 & \text{for } t = s \end{cases}$$

$$\text{Cov}(\beta_{2t}, \beta_{2s}) = \begin{cases} 0 & \text{for } t \neq s \\ \alpha_2 & \text{for } t = s \end{cases}$$

$$\text{Cov}(\beta_{1s}, \beta_{2t}) = 0 \text{ for all } t \text{ and } s$$

where β_1 and β_2 are the means of random variables β_{1t} and β_{2t} respectively and α (2x1) is the vector of their variances. The covariance of parameters is defined to be zero.

Random coefficient model (5) is reduced to the simple linear model (2) when variance of the slope coefficient β_{2t} is zero ($\alpha_2 = 0$). Therefore a test of the stability of the slope coefficient of model (2) can be conducted by estimating the variance α_2 and testing the following hypotheses:

$$(6) \quad \text{Null Hypothesis:} \quad H_0: \alpha_2 = 0$$

$$\quad \quad \quad \text{Alternative Hypothesis:} \quad H_1: \alpha_2 > 0$$

Another specification of the random coefficient model (5) can be obtained by dropping the assumption that random variables β_{1t} and β_{2t} are intertemporally independent of themselves. Yet another specification will be to drop the assumption that β_{1t} and β_{2t} are independent of each other. Details of these specifications and arguments for and against their relevance to the market model (1) are discussed in Section 4 of this chapter. Since specification (5a) is the simplest of the random coefficient models, its properties and testing of hypotheses (6) under this specification are examined in the following section.

3. RANDOM COEFFICIENT MODEL WITH INTERTEMPORAL INDEPENDENCE

Rubin (1950) derived the maximum likelihood estimates of parameters β_1 , β_2 , α_1 and α_2 for model (5a). These estimators are highly nonlinear and difficult to apply in practice. The maximum likelihood estimation of closely related models has not yielded good results. Bogue (1972) found that the likelihood contours for the parameters of his linear models obtained from a five dimensional search were highly elongated. Theil and Mennes (1959) proposed estimators for model (5a) given in equation (16) later in this chapter. Hildreth and Houck (1968) generalized these results for an arbitrary number of independent variables. They also showed that these (as well as some other) estimators of α_1 and α_2 are of the order $1/T$ and that the generalized least square estimates of the coefficient means obtained

from the estimated variances are consistent.²

Rewrite (5) as:

$$(7) \quad y = X\beta + u$$

where y is a $(Tx1)$ vector of observations on the dependent variable; x is a $(Tx2)$ matrix of the independent variables, the first column being constant 1; β is a $(2x1)$ vector of coefficient means β_1 and β_2 , and u is a $(Tx1)$ vector of disturbances.

$$(8) \quad \begin{aligned} u_t &= (\beta_{1t} - \beta_1) + (\beta_{2t} - \beta_2) x_t \\ &= \epsilon_{1t} + \epsilon_{2t} x_t \quad (t = 1, \dots, T) \end{aligned}$$

Let Θ be the covariance matrix of u . Since by assumption in model (5a), ϵ_{1t} and ϵ_{2t} are independent of each other and serially independent of themselves,

$$(9) \quad \theta_{st} = 0 \text{ for } s \neq t$$

$$\theta_{tt} = \sum_{k=1}^2 x_{tk}^2 \alpha_k = \dot{X}_{(t)} \alpha \quad (t = 1, 2, \dots, T)$$

where \dot{X} is a $(Tx2)$ matrix whose elements are squares of the corresponding elements of X , $\dot{X}_{(t)}$ is the t^{th} row of \dot{X} and α is the column vector of

²An estimate $\hat{\theta}$ of θ is of the order $1/T$ if

$$\lim_{T \rightarrow \infty} T \cdot \text{Var}(\hat{\theta}) = 0$$

and is consistent if

$$\lim_{T \rightarrow \infty} \text{Prob}((\theta - \epsilon) \leq \hat{\theta} \leq (\theta + \epsilon)) = 1$$

where ϵ is an arbitrarily small positive number.

the coefficient variances α_1 and α_2 .³

Let r be the vector of residuals from the ordinary least square (OLS) regression of y on X .

$$\begin{aligned} (10) \quad r &= (I - X(X'X)^{-1}X') y \\ &= (I - X(X'X)^{-1}X') u \\ &= M u, \quad M \text{ is the symmetric idempotent matrix of rank } (T-2) \end{aligned}$$

The covariance matrix of the residual vector r is

$$(11) \quad E r r' = M \Theta M$$

and since Θ is a diagonal matrix,

$$(12) \quad E r_t^2 = \dot{M}_{(t)} \bar{\theta} \quad (t = 1, 2, \dots, T)$$

where $\dot{M}_{(t)}$ is the t^{th} row of \dot{M} with each corresponding element of M squared and $\bar{\theta}$ is the $(T \times 1)$ vector of the diagonal elements of Θ .

Let \dot{r} be the vector of the squared residuals from (10). Then (12) can be rewritten as,

$$(13) \quad E \dot{r} = \dot{M} \bar{\theta}$$

From (9) substitute $\bar{\theta} = \dot{X} \alpha$ to obtain

$$(14) \quad E \dot{r} = \dot{M} \dot{X} \alpha$$

³The following notation is used in this chapter: If X is a matrix, \dot{X} represents the matrix obtained by squaring each element of X . Similarly \dot{r} represents the vector obtained by squaring each element of vector r . $X_{(t)}$ represents the t^{th} row of matrix X .

Let $v = \dot{r} - E \dot{r}$

$$(15) \quad \dot{\hat{r}} = \dot{M} \dot{X} \alpha + v$$

Equation (15) has the form of a linear model. Whenever $\dot{M} \dot{X}$ is of rank 2, an unbiased estimate of the variance vector α is $H \dot{r}$, where H is any left reciprocal of $\dot{M} \dot{X}$. In order to find the best linear unbiased estimate of the variance vector α , the covariance matrix of disturbance v in (15) must be known. Theil and Mennes (1959) showed that $E(vv')$ itself is a function of the unknown vector α of the coefficient variances.⁴ Thus the minimum variance unbiased estimates of α cannot be obtained. The least square estimate α^* is

$$(16) \quad \alpha^* = (\dot{X}' \dot{M} \dot{M} \dot{X})^{-1} \dot{X}' \dot{M} \dot{r}$$

Although α^* does not satisfy the requirements of the Gauss-Markov theorem for the reasons given above, Hildreth and Houck (1968) show that this estimator is of the order of $(1/T)$ under the following assumptions:

- (a). $\lim_{T \rightarrow \infty} (1/T)(\dot{X}' \dot{M} \dot{M} \dot{X})$ is finite and nonsingular,
- (b) ϵ_{1t} and ϵ_{2t} of (8) have finite fourth moments and
- (c) Sequence x_t is bounded.

α^* is an unbiased but not an efficient estimator of α . It is also not restricted to be non-negative. This is clearly an undesirable property for an estimator of a non-negative parameter. Hildreth and

⁴Theil and Mennes' treatment is limited to the case of one independent variable with a zero mean. For a more general treatment, see Hildreth and Houck (1968).

Houck (1968) propose alternative estimators which are non-negative but have a positive bias⁵. Since the primary purpose of this chapter is to test hypotheses (6), unbiasedness in estimates is very essential. For this reason, we shall examine how well hypotheses (6) can be tested by using the estimator $\tilde{\alpha}^*$ given by (16).

Standard tests of significance on estimates of the coefficients of a linear model involve the ratio of the estimated coefficient to their estimated standard error. This ratio will be called t-ratio. Under certain conditions⁶, this ratio has Student-t distribution with (T-K) degrees of freedom if K coefficients are estimated from T observations. For large degrees of freedom, Student-t distribution approaches a normal distribution with a unit variance. A normally distributed random variable with unit variance and zero mean will be greater than 1.645 with a probability of 0.05. In other words, the 95 percent one sided confidence interval on t-ratio is,

$$-\infty < t \leq 1.645$$

and the null hypothesis that the coefficient of a linear model is zero can be rejected with a probability of type I error 0.05 if the ratio of the estimated coefficient to its estimated standard error is greater than 1.645.

In the following paragraphs we deal with the problem of

⁵A simple alternative estimator $\tilde{\alpha}$ is defined by

$$\tilde{\alpha} = \max(\alpha_K^*, 0), \quad K = 1, 2$$

This estimator has a positive bias but has a lower mean square error than α does. Another non-negative estimator can be obtained by applying the restricted least squares to (15).

⁶See Graybill (1961), pp. 120-121.

estimating the standard error and computing the t-ratio for the coefficient estimate $\hat{\alpha}^*$.

The variance of $\hat{\alpha}^*$ in (16) is,

$$(17) \quad \text{Var}(\hat{\alpha}^*) = E(\hat{\alpha}^* - E\hat{\alpha}^*)(\hat{\alpha}^* - E\hat{\alpha}^*)'$$

Since $\hat{\alpha}^*$ is an unbiased estimate of α , $E\hat{\alpha}^* = \alpha$,

$$(18) \quad \text{Var}(\hat{\alpha}^*) = (\dot{X}'\dot{M}\dot{M}\dot{X})^{-1}\dot{X}'\dot{M}E(vv')\dot{M}\dot{X}(\dot{X}'\dot{M}\dot{M}\dot{X})^{-1}$$

$E(vv')$, the covariance matrix of the error term in (15) is unknown and is a function of α . A simplifying assumption is made that this matrix is an identity up to a scale factor.

$$(19) \quad E vv' = \sigma^2 I$$

which gives the covariance matrix of $\hat{\alpha}^*$

$$(20) \quad \text{Var}(\hat{\alpha}^*) = \sigma^2 (\dot{X}'\dot{M}\dot{M}\dot{X})^{-1}$$

Since σ^2 is unknown, it is replaced by its estimate

$$(21) \quad \hat{\sigma}^2 = (\dot{r} - \dot{M}\dot{X}\hat{\alpha}^*)'(\dot{r} - \dot{M}\dot{X}\hat{\alpha}^*) / (T-2)$$

An estimate of V_{α} , the variance of $\hat{\alpha}^*$ is

$$(22) \quad V_{\alpha}^* = \hat{\sigma}^2 (\dot{X}'\dot{M}\dot{M}\dot{X})^{-1}$$

V_{α}^* is a (2x2) matrix whose diagonal elements are the estimated variances of estimate $\hat{\alpha}_1^*$ and $\hat{\alpha}_2^*$. The standard error of $\hat{\alpha}_2^*$ is $\sqrt{V_{\alpha}^*_{22}}$. The t-ratio for this estimate is,

$$(23) \quad t = \hat{\alpha}_2^* / \sqrt{V_{\alpha}^*_{22}}$$

If the error term v in model (15) were normally distributed and assumption (19) had not been made about $E(vv')$, normal theory, under which t^* would have Student- t distribution with $(T-2)$ degrees of freedom, could be used. No assumption has been made about the probability distribution of the random coefficients in model (5a). Even if β_{1t} and β_{2t} were normally distributed, v in (15) would not be distributed normally because dependent variable vector r has non-negative elements (squared residuals). Under these conditions the 95% confidence interval $-\infty < t^* \leq 1.645$ is, at best, an approximation. To determine how good an approximation it is and to find the power function of the test using this confidence interval⁷, Monte Carlo experiments were conducted. The results of these experiments are described in the next section.

4. MONTE CARLO EXPERIMENTS ON RANDOM COEFFICIENT MODEL

Monte Carlo experiments were conducted to examine the behavior of statistic t^* defined in (23) and to find the power function of a test of hypotheses (6) on parameter α_2 . The test is defined by the following rule:

Reject the null hypothesis $H_0: (\alpha_2 = 0)$ if $t > 1.645$

Do not reject the null hypothesis if $t \leq 1.645$

The alternative hypothesis H_1 is $\alpha_2 > 0$

Data for Monte Carlo experiments on model (5a) was generated from pseudo-random generators. The procedure adopted is summarised in Table VI.1 and described in the following paragraphs. Since the primary purpose of conducting these experiments is to test the stability of

⁷The power function of a test is the probability of rejecting the null hypothesis when, in fact, the null hypothesis is not true. In other words, it is $(1 - \text{the probability of type II error})$.

Table VI. 1

Procedure Used for Generating Data for Monte Carlo
Experiments on Model (5a)

Variable		Value or Distribution
1. Independent Variable	x_t	$\sim N (0.01, 0.09^2)$
2. Intercept	β_{1t}	$\sim N (0, \alpha_1)$
3. Intercept Variance	α_1	$(0.06)^2$
4. Slope	β_{2t}	$\sim N (\beta_2, \alpha_2)$
5. Slope Mean	β_2	$\begin{cases} 1 \\ \sim N (1, 0.0625) \end{cases}$
6. Slope Variance	α_2	$\begin{cases} 0 \\ 0.01 \\ 0.0625 \\ 0.25 \\ 0.5675 \\ 1.0 \\ 6.25 \end{cases}$
7. Number of Observations	T	$\begin{cases} 50 \\ 100 \end{cases}$
8. Number of Replications		100

slope coefficient β in the market model (1), various parameters for data generation are chosen to approximate the real data to which the market model (1) is applied. To that extent, results from this experiment are specific to the data used in this study.

1. Independent variable x_t is normally distributed with mean 0.01 and standard deviation 0.09. The distribution, mean and standard deviation are selected to approximately conform to the characteristics of the equally weighted market return index for all stocks listed on the New York Stock Exchange⁸. This market return is variable R_m in the market model (1) and corresponds to x_t in model (5). In a given experiment, x_t 's are kept fixed for all replications.
2. Intercept β_{1t} is distributed normally mean zero ($\beta_1 = 0$) and standard deviation 0.06 ($\alpha_1 = 0.06^2$). The mean and standard deviation closely approximate the empirically estimated intercept and the standard deviation of the residual term in the market model on average. The justification for normal distribution given in footnote 8 also applies to the distribution of β_{1t} .
3. Time series of slope coefficient β_{2t} , ($t = 1, \dots, T$) for a given replication are normally and independently distributed with mean β_2 and variance α_2 .

⁸Strictly speaking, the distribution of returns on stocks has fatter tails than the normal distribution and is better described by non-gaussian members of stable symmetric class of distributions or by a Student-t distribution. See Fama (1965) and Blattberg and Gonedes (1972). For the present purposes, however, normal distribution provides a close approximation.

4. The average slope for all stocks in the market is 1. Between replications, two different treatments of slope mean β_2 are used. In the first treatment $\beta_2 = 1$ is used for all replications. Results from this experiment would be applicable if β_2 for all stocks in the market was equal to one. Since it is known that stocks differ quite substantially in their riskiness, in a second treatment, β_2 is allowed to vary from one replication to another and is distributed normally with mean 1 and standard deviation 0.25 between replications. Results from the second treatment would be applicable to stock market data for different stocks with different risk⁹.

5. Seven different values of slope variance α_2 ranging from 0.0 to 6.25 are used. $\alpha_2 = 0$ corresponds to the null hypothesis while other values correspond to the compound alternative hypothesis.

6. Two different sample sizes, $T = 50$ and $T = 100$ are examined.

7. All the results reported are from 100 replications.

The summary statistics from Monte Carlo experiments described above are shown in Table VI.2. Twenty-eight values of each statistic are obtained from a $(7 \times 2 \times 2)$ experimental design, that is, from seven different values of α_2 , two different values of T and two different treatments of slope mean between replications.

Table VI.2a shows the relative frequency with which t^* (defined

⁹As will be seen below, the two treatments do not make much difference to estimation and hypothesis testing. This, however, could not have been asserted without conducting these experiments.

Table VI.2a

Power Function - Relative Frequency of $t^* > 1.645$

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
T= 50	Slope Mean (β_2) fixed	0.06	0.07	0.17	0.45	0.79	0.89	0.98
	$\beta_2 \sim N(1, .0625)$	0.05	0.06	0.15	0.44	0.66	0.92	0.96
T= 100	Slope Mean (β_2) fixed	0.04	0.07	0.30	0.73	0.96	0.98	1.00
	$\beta_2 \sim N(1, .0625)$	0.07	0.16	0.32	0.76	0.94	0.99	1.00

Table VI.2b

Sampling Mean of t^*

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
T= 50	Slope Mean (β_2) fixed	-0.044	0.132	0.619	1.684	2.667	3.106	4.096
	$\beta_2 \sim N(1, .0625)$	-0.088	0.103	0.578	1.416	2.504	3.339	3.836
T= 100	Slope Mean (β_2) fixed	0.060	0.277	1.124	2.610	3.922	4.691	5.952
	$\beta_2 \sim N(1, .0625)$	-0.080	0.210	1.162	2.711	3.789	4.580	5.784

Table VI.2c

Sampling Median of t^*

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
T= 50	Slope Mean (β_2) fixed	-0.185	0.068	0.651	1.54	2.511	2.875	3.850
	$\beta_2 \sim N(1, .0625)$	-0.146	0.125	0.467	1.239	2.300	3.284	3.781
T= 100	Slope Mean (β_2) fixed	-0.098	0.224	0.978	2.500	4.065	4.539	5.933
	$\beta_2 \sim N(1, .0625)$	-0.158	-0.040	1.037	2.830	3.598	4.559	5.667

Table VI.2d

Sampling Variance of t^*

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
T= 50	Slope Mean (β_2) fixed	0.826	0.877	1.292	1.800	1.811	1.599	2.768
	$\beta_2 \sim N(1, .0625)$	0.855	1.101	1.026	1.627	2.213	1.718	2.040
T= 100	Slope Mean (β_2) fixed	0.985	1.079	1.583	2.276	1.814	2.686	1.855
	$\beta_2 \sim N(1, .0625)$	0.986	1.535	1.302	1.965	1.990	1.983	1.986

Table VI.2e

Sampling Mean of α_1^* (x 100)

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
T= 50	Slope Mean (β_2) fixed	0.353	0.369	0.369	0.381	0.380	0.390	0.512
	$\beta_2 \sim N(1, .0625)$	0.378	0.364	0.367	0.383	0.387	0.280	0.613
T= 100	Slope Mean (β_2) fixed	0.357	0.356	0.355	0.370	0.368	0.365	0.191
	$\beta_2 \sim N(1, 0.0625)$	0.369	0.357	0.347	0.350	0.386	0.372	0.365

Table VI.2f

Sampling Mean Square Error of α_1^* ($\times 10^6$)

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
T= 50	Slope Mean (β_2) fixed	0.584	1.033	1.054	2.470	2.856	8.167	206.0
	$\beta_2 \sim N(1, .0625)$	0.842	0.656	1.077	1.918	3.933	16.39	126.8
T= 100	Slope Mean (β_2) fixed	0.469	0.492	0.582	0.971	2.034	5.745	165.5
	$\beta_2 \sim N(1, .0625)$	0.553	0.527	0.489	0.835	2.013	5.310	128.0

Table VI.2g

Sampling Mean of α_2^*

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
T= 50	Slope Mean (β_2) fixed	0.000	0.009	0.056	0.249	0.547	0.937	6.022
	$\beta_2 \sim N(1, .0625)$	-0.007	0.014	0.060	0.182	0.537	1.136	5.659
T= 100	Slope Mean (β_2) fixed	0.002	0.014	0.070	0.241	0.535	1.004	6.332
	$\beta_2 \sim N(1, 0.0625)$	-0.006	0.013	0.072	0.252	0.510	0.969	6.254

Table VI.2h

Sampling Mean Square Error of α_2^*

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
T= 50	Slope Mean (β_2) fixed	0.006	0.007	0.011	0.060	0.127	0.378	10.43
	$\beta_2 \sim N(1, .0625)$	0.007	0.009	0.011	0.037	0.193	0.686	8.190
T= 100	Slope Mean (β_2) fixed	0.003	0.003	0.007	0.025	0.071	0.243	7.572
	$\beta_2 \sim N(1, .0625)$	0.003	0.005	0.005	0.029	0.066	0.193	5.587

in equation (23)) falls in the critical region ($t > 1.645$). The first column of the table corresponds to the null hypothesis $\alpha_2 = 0$. Relative frequencies observed in this column are close to the theoretical probability of 0.05 if t^* is normally distributed with mean zero and unit variance. Frequencies in the last six columns in each row can be interpreted as the power function ($1 -$ the relative frequency of type II error) of the critical region ($t > 1.645$) with the numbers in the first column representing the corresponding type I error frequency. Four power functions are plotted in Figure VI.1. The power of the test increases considerably when sample size T is doubled from 50 to 100. For example, the relative frequency of rejection of the null hypothesis when α_2 is equal to 0.0625 is almost doubled from 0.15 to 0.32 when the sample size is doubled.

The use of different values of α_2 for each replication seems to make no difference to the discriminatory power of the test or to any other estimate. Comparisons between the first and second rows and between the third and fourth rows of each part of Table VI.2 will confirm this view.

Sampling mean, median and variance of t^* are given in Parts b, c and d respectively of Table VI.2. The mean and median of t^* move sharply away from zero as α_2 moves away from zero. The difference between mean and median is small but quite consistently positive, indicating some rightward skewness in the distribution of t^* .

Sampling means and mean square errors of $\hat{\alpha}_1^*$ and $\hat{\alpha}_2^*$ are given in Parts e, f, g, and h respectively of Table VI.2. For small values of slope variance, estimates of α_1 are remarkably accurate.

Figure VI. 1a

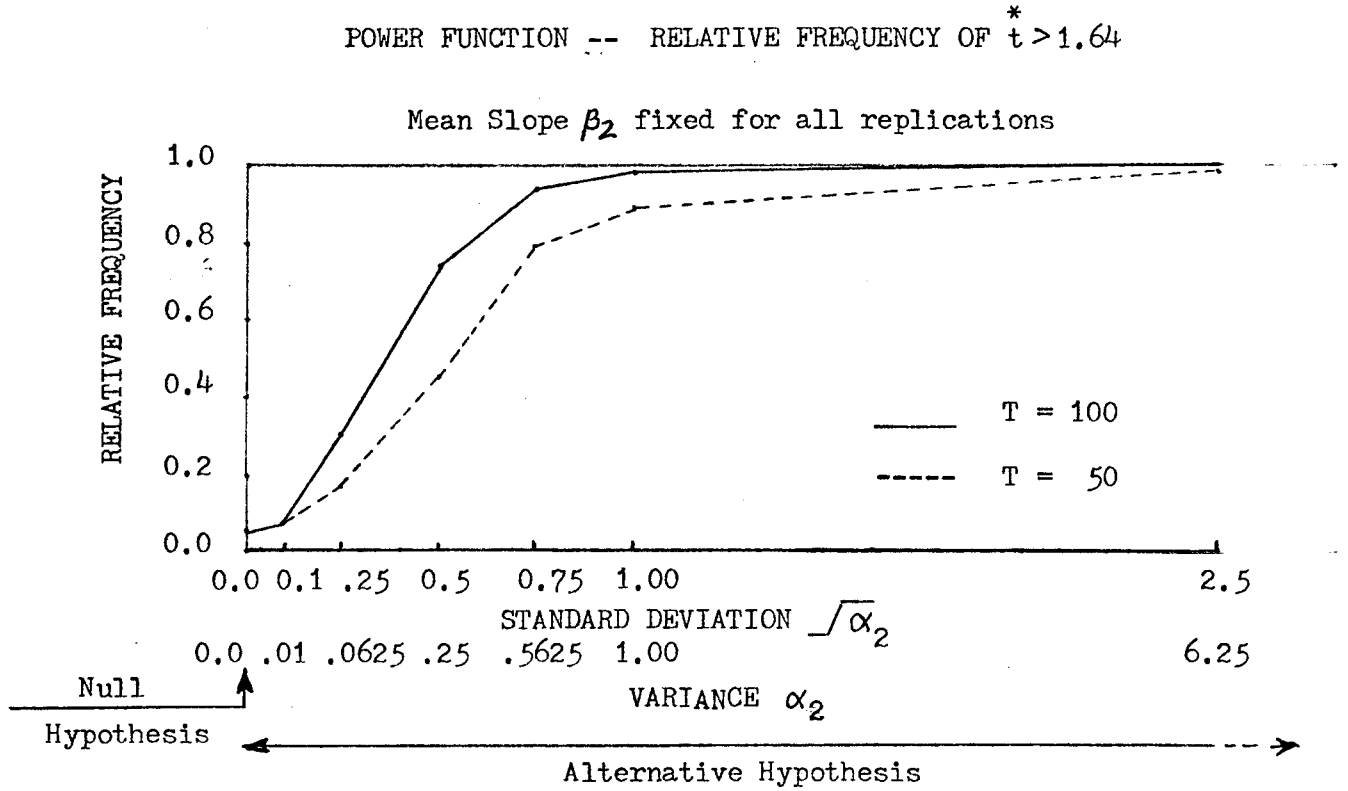
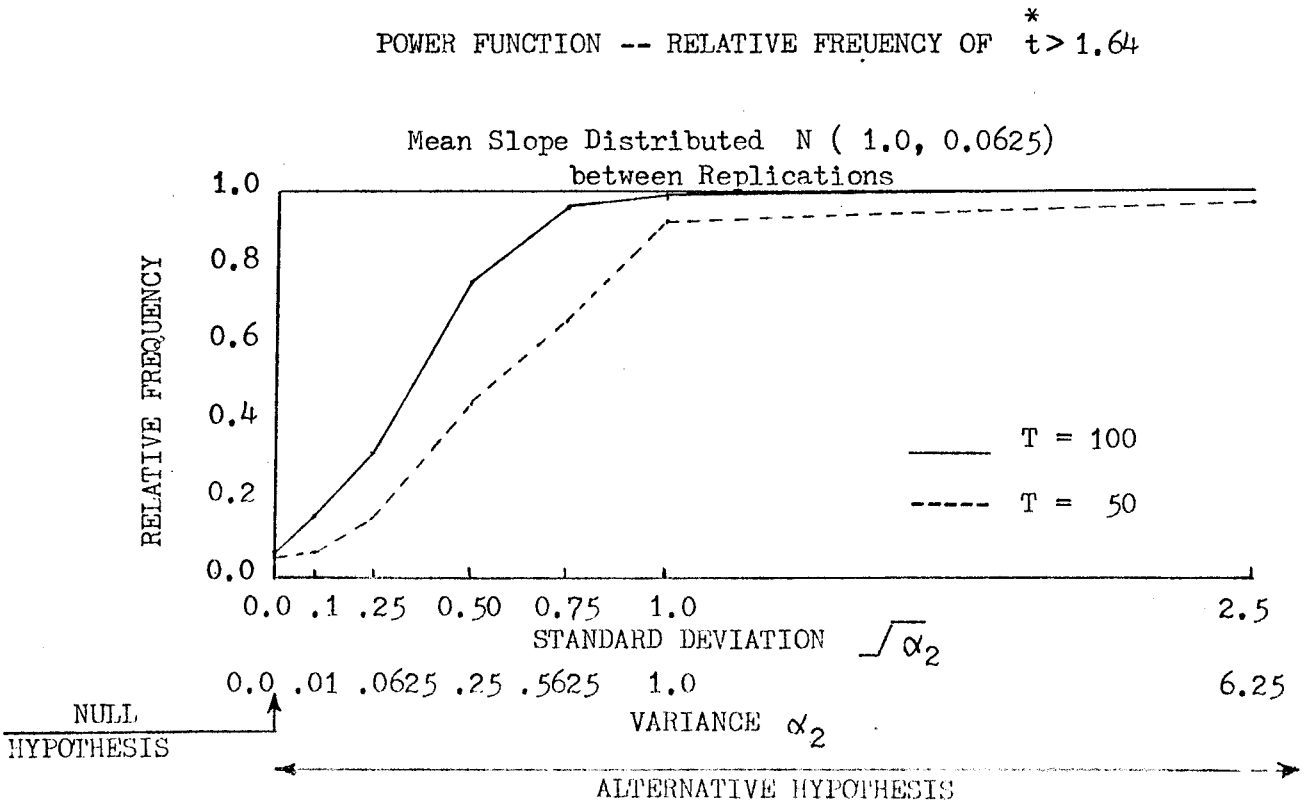


Figure VI. 1b



As the slope variance increases, these estimates become increasingly diffuse.

The Monte Carlo experiments and the analysis given in this section show how tests of hypotheses (6) about the stability of the slope coefficient of linear model (5a) can be conducted. Whether the discriminatory power provided by this test is adequate or not depends on the magnitude of the instability of the slope (variance) that is to be detected. The power of the test can be increased by adding more observations.

In the following section, other specifications of the random coefficient model (5) are considered. In these specifications, mentioned briefly in Section 2 above, certain independence assumptions are dropped because actual stock market data do not seem to fulfil these assumptions.

5. RANDOM COEFFICIENT MODEL WITH SERIAL DEPENDENCE

In the random coefficient model (5a) considered in the last section, there are three independence assumptions:

- (a) Random intercept β_{1t} is distributed independently itself,

$$E(\beta_{1t} - \beta_1)(\beta_{1s} - \beta_1) = 0 \text{ for } s \neq t.$$
- (b) Random slope β_{2t} is distributed independently of itself,

$$E(\beta_{2t} - \beta_2)(\beta_{2s} - \beta_2) = 0 \text{ for } s \neq t$$
- (c) The intercept and slope are distributed independently of each other, $E(\beta_{1t} - \beta_1)(\beta_{2s} - \beta_2) = 0$ for all t and s .

Serial dependence in intercept β_{1t} implies serial dependence in the dependent variable y_t . The propriety of the independence assumption (a) in this study depends on the actual behavior of the

dependent variable R_t in the market model (1). R_t is the total return on a stock during month t . If the market price data indicate that R_t is serially correlated, it will be appropriate to drop the assumption of serial independence and consider only those models which account for serial dependence. However, there is substantial empirical evidence in the finance literature to support the view that monthly stock price returns have no significant serial correlation.¹⁰ This justifies assumption (a) in the random coefficient model.

Slope β_{2t} in the random coefficient model represents the relative risk parameter in the market model. The relative risk of a firm's stock is a characteristic of the firm's assets, the business environment and expectations about future prospects. While all these factors are liable to change over time, it seems quite improbable that they will fluctuate randomly from month to month without any serial dependence. A firm's assets, business environment and future prospects in a given month are more likely to be similar to these characteristics in the next month than in the next year or decade. Therefore by prior considerations alone, it seems quite appropriate that the model should allow for serial dependence in the relative risk (represented by the slope parameter). Empirical evidence on the presence of serial dependence in the relative risk is provided by Fisher (1970) and Bogue (1972). Hence the assumption of serial independence in the slope coefficient β_{2t} is dropped in the random coefficient model to be considered in this section.

¹⁰See Fama (1965)

The third independence assumption in model (5a) is concerned with the relationship between coefficients β_{1t} and β_{2t} . There is no a priori reason why this assumption should be inappropriate for the market model. Its elimination will only complicate the model further.

Another random coefficient model can now be defined as follows:

$$(24) \quad y_t = (\beta_1 + \varepsilon_{1t}) + (\beta_2 + \varepsilon_{2t}) x_t \quad (t = 1, 2, \dots, T)$$

$$E(\varepsilon_{1t}) = 0$$

$$E(\varepsilon_{2t}) = 0$$

$$E(\varepsilon_{1s} \varepsilon_{1t}) = 0, \quad t \neq s$$

$$E(\varepsilon_{1t}^2) = \alpha_1$$

$$E(\varepsilon_{2t}^2) = \alpha_2$$

$$E(\varepsilon_{2t} \varepsilon_{2s}) = \alpha_2 \cdot (\rho)^{|t-s|}$$

ρ is the serial correlation coefficient of ε_{2t} ,

$$(25) \quad \varepsilon_{2t} = \rho \varepsilon_{2,t-1} + w_t$$

$$\text{Var}(\varepsilon_{2t}) = \alpha_2 = \text{Var}(w_t)/(1 - \rho^2)$$

$$(26) \quad \text{Var}(w_t) = (1 - \rho^2) \alpha_2$$

When $\rho = 1$, the variance of ε_{2t} is not finite. The error term in (24) can be written as,

$$(27) \quad v_t = (\varepsilon_{1t} + \varepsilon_{2t} x_t) \quad (t = 1, 2, \dots, T)$$

Variance of the error term v is

$$(28) \quad \textcircled{H} = E (\epsilon_1 + \epsilon_2 x) (\epsilon_1 + \epsilon_2 x)'$$

$$= \begin{bmatrix} \alpha_1 + \alpha_2 x_1^2 & \rho \alpha_2 x_1 x_2 & \dots & \dots & \rho^{T-1} \alpha_2 x_T x_1 \\ \rho \alpha_2 x_1 x_2 & \alpha_1 + \alpha_2 x_2^2 & \dots & \dots & \rho^{T-2} \alpha_2 x_T x_2 \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ \rho^{T-1} \alpha_2 x_1 x_T & \dots & \dots & \dots & \alpha_1 + \alpha_2 x_T^2 \end{bmatrix}$$

$$= \textcircled{1} + \textcircled{2}$$

where

$$(29) \quad \textcircled{1} = \alpha_1 I_T$$

and ij^{th} element of $\textcircled{2}$ is

$$(30) \quad \textcircled{2}_{ij} = \alpha_2 x_i x_j (\rho)^{|i-j|}$$

From (11) we have,

$$(31) \quad E r r' = M \textcircled{H} M = M \textcircled{1} M + M \textcircled{2} M$$

$$E r_t^2 = m_{tt} \alpha_1 + \left[\sum_{i=1}^T \sum_{j=1}^T m_{ti} m_{tj} x_i x_j (\rho)^{|i-j|} \right] \alpha_2, \quad t = 1, 2, \dots, T.$$

$$\text{Let } v_t = r_t^2 - E r_t^2, \quad t = 1, 2, \dots, T$$

$$r_t^2 = E r_t^2 + v_t, \quad t = 1, 2, \dots, T.$$

$$(32) \quad \dot{r} = A \alpha + v$$

where A is $(T \times 2)$ matrix of coefficients of α_1 and α_2 as defined in (31).

(32) has the form of a linear model and an unbiased estimate of α is,

$$(33) \quad \tilde{\alpha} = (A'A)^{-1} A'r$$

Estimate $\tilde{\alpha}$ can be computed if A , which is a function of x 's and ρ is known. When ρ is not known, a simple procedure suggests itself--search over feasible values of ρ and select the value which minimizes the residual sum of the squared residuals in regression (33) as the estimate of ρ . Denote this estimate by $\bar{\rho}$. The corresponding estimate of α is $\bar{\alpha}$.

$$(34) \quad \bar{\alpha} = (A'_{(\bar{\rho})} A_{(\bar{\rho})})^{-1} A'_{(\bar{\rho})} \dot{r}$$

where $A_{(\bar{\rho})}$ is matrix A computed with $\rho = \bar{\rho}$.

To estimate the standard error of estimation for $\tilde{\alpha}$ and $\bar{\alpha}$, again the simplifying assumption is made that the covariance matrix of the error term v in (32) is of the form $\sigma^2 I$. Then

$$(35) \quad \tilde{\sigma}^2 = (\dot{r} - A\tilde{\alpha})' (\dot{r} - A\tilde{\alpha}) / (T-2)$$

$$(36) \quad \text{Var} (\tilde{\alpha}) = \tilde{\sigma}^2 (A'A)^{-1} \equiv \tilde{V}_{\alpha}$$

$$(37) \quad \tilde{t} = \tilde{\alpha}_2 / \sqrt{\tilde{V}_{\alpha 22}}$$

Similarly for estimator (34),

$$(38) \quad \bar{\sigma}^2 = (\dot{r} - A_{(\bar{\rho})}\bar{\alpha})' (\dot{r} - A_{(\bar{\rho})}\bar{\alpha}) / (T-2)$$

$$(39) \quad \text{Var} (\bar{\alpha}) = \bar{\sigma}^2 (A'_{(\bar{\rho})} A_{(\bar{\rho})})^{-1} \equiv \bar{V}_{\alpha}$$

$$(40) \quad \bar{t} = \bar{\alpha}_2 / \sqrt{\bar{V}_{\alpha 22}}$$

For the random coefficient model with serial dependence (24), three different estimators have been proposed. Corresponding to each estimator, is a procedure for testing hypotheses (6) about the variance of slope β_{2t} . To summarize, these three procedures are:

Procedure 1:- Ignore the presence of serial correlation in the slope (i.e., assume it is zero). Estimate α by $\hat{\alpha}^*$ as given in (16) and compute \hat{t}^* as defined by (23). Reject the null hypothesis ($\alpha_2 = 0$) if \hat{t}^* is greater than 1.645.

Procedure 2:- If serial correlation coefficient of slope (ρ) is known or can be given a prior value, use (32) and (36) to estimate α by $\tilde{\alpha}$ and t by \tilde{t} respectively. Reject the null hypothesis ($\alpha_2 = 0$) if t is greater than 1.645

Procedure 3:- If the serial correlation coefficient ρ is unknown and cannot be ignored, use equations (33) and (40) to make estimates $\bar{\alpha}$ and \bar{t} respectively. Reject the null hypothesis ($\alpha_2 = 0$) if \bar{t} is greater than 1.645.

The properties of these three procedures for the purpose of estimating coefficient variance α_2 and for testing hypothesis about this parameter are examined in the next section with the help of Monte Carlo experiments.

6. MONTE CARLO EXPERIMENTS ON RANDOM COEFFICIENT MODEL WITH SERIAL DEPENDENCE

Preliminary runs of Monte Carlo experiment on Procedure 3 indicated that estimate $\bar{\rho}$ does not provide a good estimate of ρ . Since the estimation of $\bar{\rho}$ involves search for that value of ρ which minimizes the sum of squared residuals, the sums of squared

residuals were computed for 11 values of ρ between 0 and 0.99. The sum of squared residuals was found to be minimum at one or the other extreme of the range of the search in most instances and showed little relationship to the actual degree of serial correlation present in the generated data. Moreover, the values of estimate $\bar{\rho}$ close to unity, resulted in very large estimates of $\bar{\alpha}$ which differed from estimates of $\bar{\alpha}$ obtained from those replications when $\bar{\rho}$ was small, by several orders of magnitude. The reason is that for a given step variance in time series, as serial correlation approaches unity (random walk), variance approaches infinity. Thus estimate $\bar{\rho}$ and associated estimates $\bar{\alpha}$ are quite unstable and are not of much use. Since the computational costs of search for $\bar{\rho}$ are quite high and since the major anticipated advantage of this procedure was the estimation of ρ , which is not fulfilled, the results from the application of this procedure are not reported in this study.

The design of Monte Carlo experiment to examine the properties of Procedures 1 and 2 (defined in Section 5), is quite similar to the design used in Section 3 to examine the properties of model (5a). Parameter values have been chosen to generate data which are comparable to monthly stock price return data used in the market model. The procedure for the generation of data is tabulated in Table VI.3 and described below:

1. Independent variable x_t is a normally distributed pseudo random variable with mean 0.01 and standard deviation 0.09.

All experiments are conducted with the same set of values of x .

The 50 values of the independent variable and their

Table VI. 3

Procedure used for Generating Data for Monte Carlo Experiments on
Random Coefficients Model with Serial Correlation (24)

Variable		Value or Distribution							
1. Independent Variable	x_t	$\sim N (0.01, 0.09^2)$							
2. Intercept	β_{1t}	$\sim N (0, \alpha_1)$							
3. Intercept Variance	α_1	0.06^2							
4. Slope	β_{2t}	$\sim N (\beta_2, \alpha_2) , \text{Cov} (\beta_{2t}, \beta_{2,t+1}) = \rho \alpha_2$							
5. Slope Mean	β_2	1							
6. Slope Variance	α_2	<table border="1"> <tr><td>0.0</td></tr> <tr><td>0.01</td></tr> <tr><td>0.0625</td></tr> <tr><td>0.25</td></tr> <tr><td>0.5675</td></tr> <tr><td>1.0</td></tr> <tr><td>6.25</td></tr> </table>	0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
0.0									
0.01									
0.0625									
0.25									
0.5675									
1.0									
6.25									
7. Serial Correlation of Slope		<table border="1"> <tr><td>0.0</td></tr> <tr><td>0.707</td></tr> <tr><td>0.90</td></tr> <tr><td>0.95</td></tr> <tr><td>0.99</td></tr> <tr><td>0.995</td></tr> </table>	0.0	0.707	0.90	0.95	0.99	0.995	
0.0									
0.707									
0.90									
0.95									
0.99									
0.995									
8. Number of Observations	T	50							
9. Number of Replications		100							

sampling mean, standard deviation and serial correlation are given in Appendix III.

2. Intercept β_{1t} , $t = 1, \dots, T$, is normally and independently distributed with mean zero ($\beta_1 = 0$) and standard deviation 0.06 ($\alpha_1 = 0.06^2$).
3. Slope β_{2t} , $t = 1, \dots, T$, for a given replication is distributed normally with mean β_2 , variance α_2 and serial correlation ρ .
4. Slope mean β_2 for all replications is 1.
5. Seven different values of slope variance α_2 between 0.0 and 6.25 are used. $\alpha_2 = 0$ corresponds to the null hypothesis and the remaining six values lie in the range of the compound alternative hypothesis.
6. Six different values of ρ between 0.0 and 0.995 are used. Autoregressive equation (25) is used to generate the slope distribution term ϵ_{2t} . The variance of the random variable w_t is calculated from α_2 and ρ by equation (26).
7. Sample size T is 50.
8. All the results reported are from 100 replications.

Summary statistics from Monte Carlo experiments on estimation Procedures 1 and 2 described above are presented in Table VI.4. In the remaining parts of this section these results are discussed.

Table VI.4a shows the relative frequency of the rejection of the null hypothesis with a critical region ($t > 1.645$) for both estimation procedures. Two features of these figures are worth noting:

Table VI.4a

Power Function - Relative Frequency of $t > 1.645$

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
Estimation Procedure used	(ρ)							
Procedure 1: Estimators $\hat{\alpha}$ and \hat{t} assuming serial correlation (ρ) is zero	0.00	0.06	0.07	0.17	0.45	0.79	0.89	0.98
	0.707	0.06	0.03	0.22	0.50	0.76	0.85	0.93
	0.90	0.06	0.09	0.16	0.48	0.65	0.79	0.96
	0.95	0.06	0.10	0.09	0.36	0.56	0.77	0.95
	0.99	0.06	0.07	0.05	0.18	0.23	0.41	0.89
	0.995	0.06	0.07	0.06	0.11	0.18	0.19	0.74
Procedure 2: Estimators $\tilde{\alpha}$ and \tilde{t} assuming serial correlation (ρ) is known	0.00	0.06	0.07	0.17	0.45	0.79	0.89	0.98
	0.707	0.06	0.03	0.22	0.49	0.73	0.84	0.93
	0.90	0.06	0.09	0.18	0.47	0.66	0.80	0.94
	0.95	0.06	0.07	0.16	0.40	0.55	0.78	0.90
	0.99	0.06	0.06	0.11	0.22	0.27	0.44	0.85
	0.995	0.06	0.07	0.10	0.15	0.18	0.29	0.69

Table VI.4b

Sampling Means of Estimated t

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
Estimation Procedure used	(ρ)							
Procedure 1: Estimators $\hat{\alpha}$ and \hat{t} assuming serial correlation (ρ) is zero	0.00	-0.044	0.132	0.619	1.684	2.667	3.106	4.096
	0.707	-0.044	0.099	0.789	1.775	2.840	3.089	4.119
	0.90	-0.044	0.280	0.415	1.586	2.243	3.077	4.239
	0.95	-0.044	0.107	0.354	1.251	2.000	2.558	3.906
	0.99	-0.044	0.048	0.059	0.512	0.896	1.343	3.425
	0.995	-0.044	0.037	0.018	0.306	0.566	0.842	2.666
Procedure 2: Estimators $\tilde{\alpha}$ and \tilde{t} assuming serial correlation (ρ) is known	0.00	-0.044	0.132	0.619	1.684	2.667	3.106	4.096
	0.707	-0.044	0.102	0.812	1.780	2.870	3.107	4.126
	0.90	-0.044	0.256	0.446	1.575	2.253	3.209	4.465
	0.95	-0.044	0.144	0.404	1.325	2.295	2.903	4.363
	0.99	-0.044	0.043	0.194	0.684	1.137	1.541	4.285
	0.995	-0.044	0.035	0.145	0.447	0.699	0.945	3.355

Table VI.4c

Sampling Medians of Estimated t

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.00	6.25
Estimation Procedure used	(ρ)							
Procedure 1: Estimators $\hat{\alpha}$ and \hat{t} assuming serial correlation (ρ) is zero	0.00	-0.185	0.068	0.651	1.540	2.511	2.875	3.850
	0.707	-0.185	0.002	0.743	1.597	2.576	2.803	3.924
	0.90	-0.185	0.238	0.300	1.523	2.364	3.100	4.315
	0.95	-0.185	0.176	0.229	1.210	1.741	2.552	3.727
	0.99	-0.185	-0.007	-0.072	0.334	0.855	1.276	3.441
	0.995	-0.185	-0.030	-0.030	0.173	0.566	0.895	2.626
Procedure 2: Estimators $\tilde{\alpha}$ and \tilde{t} assuming serial correlation (ρ) is known	0.00	-0.185	0.068	0.651	1.540	2.511	2.877	3.850
	0.707	-0.185	0.034	0.807	1.559	2.629	2.701	3.874
	0.90	-0.185	0.149	0.303	1.455	2.273	3.105	4.416
	0.95	-0.185	0.050	0.268	1.228	1.863	2.700	4.203
	0.99	-0.185	-0.058	-0.027	0.491	0.778	1.292	3.982
	0.995	-0.185	-0.072	-0.112	0.376	0.419	0.775	3.101

Table VI.4d

Sampling Variance of Estimated t

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.00	6.25
Estimation Procedure used	(ρ)							
Procedure 1: Estimators $\hat{\alpha}$ and \hat{t} assuming serial correlation (ρ) is zero	0.00	0.826	0.877	1.292	1.800	1.811	1.599	2.768
	0.707	0.826	0.831	1.618	1.638	2.613	2.429	2.641
	0.90	0.826	1.117	1.483	1.418	2.294	2.512	2.356
	0.95	0.826	1.067	1.199	1.521	2.749	1.881	2.421
	0.99	0.826	1.028	1.081	1.303	1.839	1.274	2.285
	0.995	0.826	1.028	1.042	1.123	1.590	1.983	2.350
Procedure 2: Estimators $\tilde{\alpha}$ and \tilde{t} assuming serial correlation (ρ) is known	0.00	0.826	0.877	1.292	1.800	1.811	1.599	2.768
	0.707	0.826	0.824	1.663	1.734	2.841	2.672	2.930
	0.90	0.826	0.948	1.477	1.504	2.412	2.923	3.519
	0.95	0.826	1.140	1.323	1.874	3.642	3.465	4.231
	0.99	0.826	1.056	1.383	1.656	3.310	2.422	7.247
	0.995	0.826	1.070	1.285	1.320	2.392	1.636	6.700

Table VI.4e
 Sampling Means of Estimated α_1 ($\times 10^2$)

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.00	6.25
Estimation Procedure used	(ρ)							
Procedure 1: Estimators $\hat{\alpha}$ and \hat{t} assuming serial correlation (ρ) is zero	0.00	0.353	0.369	0.369	0.381	0.378	0.390	0.512
	0.707	0.353	0.364	0.342	0.360	0.335	0.338	0.286
	0.90	0.353	0.335	0.360	0.358	0.360	0.323	0.355
	0.95	0.353	0.346	0.358	0.351	0.345	0.367	0.479
	0.99	0.353	0.360	0.365	0.363	0.337	0.351	0.309
	0.995	0.353	0.361	0.365	0.364	0.339	0.353	0.331
Procedure 2: Estimators $\tilde{\alpha}$ and \tilde{t} assuming serial correlation (ρ) is known	0.00	0.353	0.369	0.369	0.381	0.378	0.390	0.512
	0.707	0.353	0.364	0.342	0.364	0.340	0.348	0.362
	0.90	0.353	0.337	0.360	0.366	0.373	0.328	0.429
	0.95	0.353	0.344	0.356	0.356	0.347	0.377	0.527
	0.99	0.353	0.361	0.360	0.359	0.338	0.360	0.349
	0.995	0.353	0.361	0.359	0.361	0.342	0.359	0.356

Table VI.4f
 Sampling Mean Square Error of Estimated α_1 ($\times 10^6$)

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.00	6.25
Estimation Procedure used	(ρ)							
Procedure 1: Estimators $\hat{\alpha}$ and \hat{t} assuming serial correlation (ρ) is zero	0.00	0.584	1.033	1.054	2.470	2.856	8.167	206.1
	0.707	0.584	0.722	1.009	1.540	5.291	7.200	251.1
	0.90	0.584	0.761	0.896	1.137	2.410	5.348	126.3
	0.95	0.584	0.695	1.076	0.979	1.892	3.617	55.56
	0.99	0.584	1.030	0.978	1.364	0.996	0.951	5.634
	0.995	0.584	1.029	0.962	1.341	0.909	0.819	2.661
Procedure 2: Estimators $\tilde{\alpha}$ and \tilde{t} assuming serial correlation (ρ) is known	0.00	0.584	1.033	1.054	2.470	2.856	8.167	206.1
	0.707	0.584	0.711	1.002	1.377	5.488	7.547	270.9
	0.90	0.584	0.678	0.961	1.135	2.442	6.289	143.0
	0.99	0.584	0.877	0.902	1.240	0.979	1.096	9.786
	0.995	0.584	0.867	0.871	1.182	0.865	0.839	3.852

Table VI.4g
Sampling Means of Estimated α_2

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.00	6.25
Estimation Procedure used	(ρ)							
Procedure 1: Estimators $\hat{\alpha}$ and \hat{t} assuming serial correlation (ρ) is zero	0.00	0.000	0.009	0.056	0.249	0.546	0.937	6.022
	0.707	0.000	0.007	0.082	0.234	0.587	0.900	5.764
	0.90	0.000	0.024	0.039	0.204	0.395	0.771	4.442
	0.95	0.000	0.013	0.031	0.145	0.313	0.556	3.063
	0.99	0.000	0.003	0.002	0.051	0.100	0.162	0.985
	0.995	0.000	0.002	0.012	0.027	0.058	0.088	0.513
Procedure 2: Estimators $\tilde{\alpha}$ and \tilde{t} assuming serial correlation (ρ) is known	0.00	0.000	0.009	0.056	0.249	0.546	0.937	6.022
	0.707	0.000	0.007	0.090	0.252	0.636	0.967	6.187
	0.90	0.000	0.029	0.054	0.266	0.523	1.060	6.014
	0.95	0.000	0.030	0.061	0.260	0.592	1.035	5.679
	0.99	0.000	0.014	0.061	0.347	0.614	0.941	5.845
	0.995	0.000	0.020	0.078	0.378	0.648	0.932	5.660

Table VI.4h
Sampling Mean Square Error of Estimated α_2

Slope Variance (α_2)		0.0	0.01	0.0625	0.25	0.5675	1.00	6.25
Estimation Procedure used	(ρ)							
Procedure 1: Estimators $\hat{\alpha}$ and \hat{t} assuming serial correlation (ρ) is zero	0.00	0.006	0.006	0.011	0.060	0.127	0.378	10.43
	0.707	0.006	0.006	0.018	0.037	0.210	0.479	13.93
	0.90	0.006	0.008	0.011	0.034	0.133	0.402	11.79
	0.95	0.006	0.008	0.010	0.036	0.179	0.420	15.65
	0.99	0.006	0.007	0.012	0.054	0.244	0.724	28.50
	0.995	0.006	0.007	0.012	0.060	0.265	0.851	33.15
Procedure 2: Estimators $\tilde{\alpha}$ and \tilde{t} assuming serial correlation (ρ) is known	0.00	0.006	0.006	0.011	0.059	0.127	0.378	10.43
	0.707	0.006	0.007	0.021	0.045	0.257	0.573	17.06
	0.90	0.006	0.012	0.022	0.057	0.221	0.753	17.45
	0.95	0.006	0.030	0.029	0.091	0.386	0.872	22.06
	0.99	0.006	0.184	0.237	0.518	1.040	1.188	25.94
	0.995	0.006	0.628	0.755	1.082	2.045	1.853	27.72

1. For any given value of slope variance α_2 , the power of the test is highest when no serial correlation exists ($\rho = 0$) and declines progressively as higher degrees of serial correlation are introduced as can be seen by reading down any of the columns of Table VI. 4a. For example, for $\alpha_2 = 0.25$, the relative frequency of the rejection of the null hypothesis is 0.45 when serial correlation is zero. This relative frequency declines to 0.17 when serial correlation between adjacent slope coefficients is raised to 0.995. Thus the discriminatory power of both the procedures declines considerably in the presence of a high degree of serial correlation.

2. Surprisingly, the use of two estimation procedures,--one assuming ρ is zero and the other assuming that its true value is known, makes little difference to the power of the test. This can be confirmed by comparing relative frequencies of the rejection of the null hypothesis in the top (for Procedure 1) and bottom (for Procedure 2) half of Table VI.4a. This is not to say that the model is not sensitive to serial correlation or that the two estimation procedures are very similar. Estimates of slope variance α_2 from the two procedures differ quite substantially, as can be seen in Table VI.4g. Corresponding differences in estimated standard errors of estimates of α_2 from the two procedures make the t-ratios quite similar. Since the hypothesis test depends on the t-ratio and not on the estimate

of coefficient α_2 , the two procedures have about the same power function. This feature is quite advantageous for the purpose of hypothesis testing because often, the degree of serial correlation present may be unknown. These results indicate that tests of significance on slope variance can be conducted without loss of efficiency, even when serial correlation is present but its magnitude is unknown.

The power functions of Procedure 1 for six different degrees of serial correlation are drawn in Figure VI. 2. Since power functions for Procedure 2 are almost identical they have not been drawn.

Tables VI.4b, VI.4c and VI.4d show the sampling means, medians and variances of the estimated t in the experiment. Sample means are usually a little higher than the medians which indicates some rightward skewness in the distribution of estimates of the t -ratio. The variance of the estimated t is higher when there is a higher degree of serial correlation. This is probably the reason for some loss of power of the test under higher serial correlation.

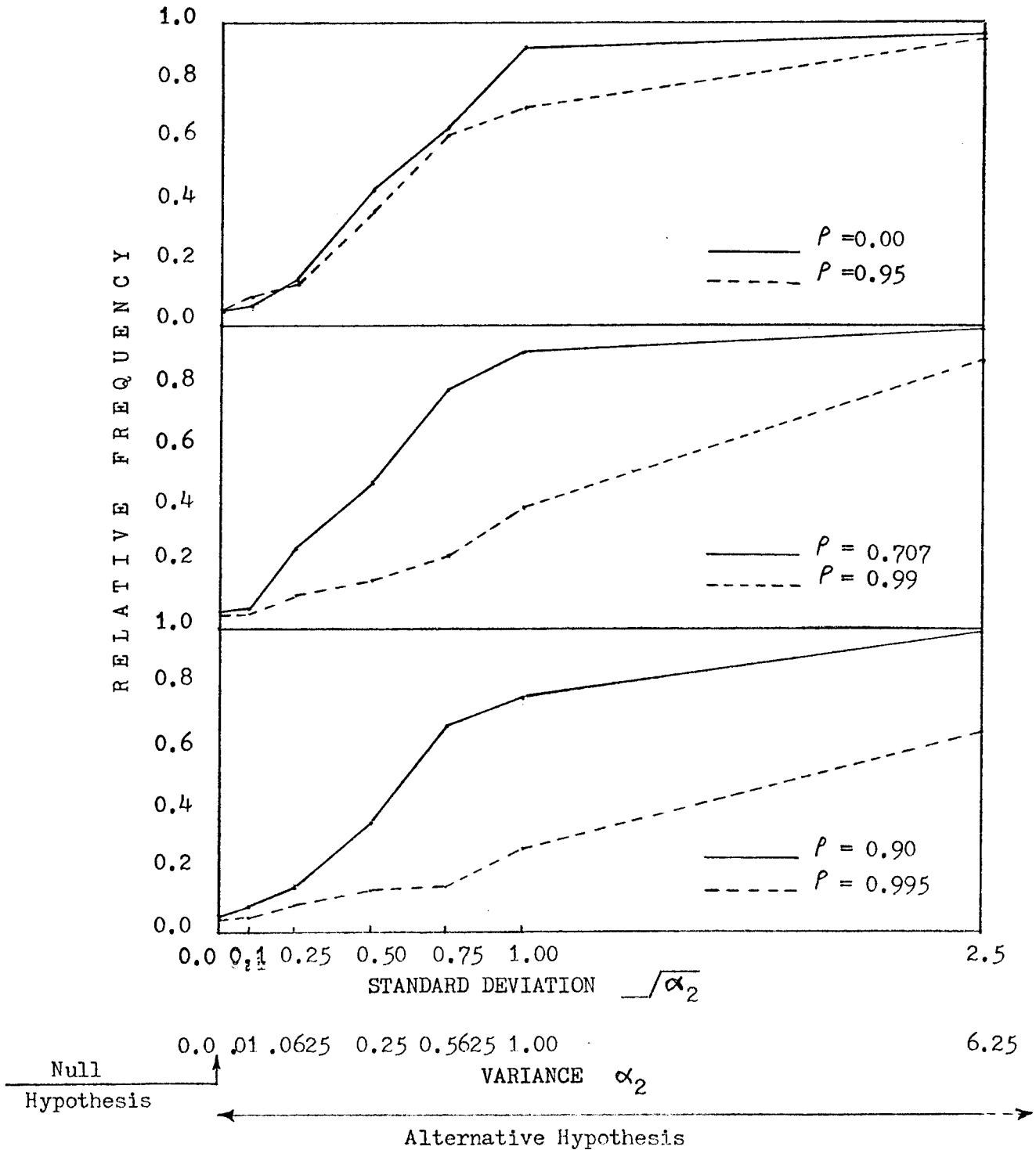
Tables VI.4e, VI.4f, VI.4g and VI.4h show the sampling means and mean square errors of the estimates of the slope and intercept variances α_1 and α_2 . The estimate of α_1 is much more accurate (low mean square error) under high serial correlation than under no serial correlation. Procedure 2, in which ρ is assumed to be known, provides an unbiased estimate of α_2 but for Procedure 1, when serial correlation is assumed to be zero, estimate α_2^* has a substantial negative bias. The probable reason for this is that in a moderate sample size (50 in this case) with very high serial correlation,

Figure VI. 2

POWER FUNCTION OF PROCEDURE 1

UNDER VARIOUS DEGREES OF SERIAL CORRELATION

RELATIVE FREQUENCY OF $t^* > 1.64$



sampling variance is very likely to understate the true variance. This bias will slowly disappear as the sample size is increased, the rate of decrease in the bias depending on the degree of serial correlation.¹¹

This downward bias in α_2^* , however, does not affect the value of t^* because the estimated variance of α_2^* also is proportionately low.

The estimation procedures discussed in the previous sections and the Monte Carlo experiments given in this section present a framework in which market model (1) can be tested on stock price data to determine if the relative risk of stocks of the firms which changed their accounting methods, was stable during the years surrounding this accounting event. In the next section of this chapter, the estimation procedures described above are applied to the stock price data and empirical evidence on changes in risk of these stocks is presented.

¹¹That the small and moderate sample estimates of the variances of serially correlated series understate the population variance can be seen from empirical runs over six different series with unit variance but with varying degrees of serial correlation. For very high serial dependence, even large samples have to be very large before this downward bias can become reasonably small.

Estimated Variance

Sample size	10	50	100	500
Serial correlation coefficient				
0.00	-	0.9416	1.0046	1.0048
0.707	0.5664	0.7685	0.6592	0.9614
0.90	0.1064	0.6274	0.5779	0.9604
0.99	0.0111	0.0271	0.1071	0.9585
0.995	0.0182	0.0428	0.0878	0.3553
0.999	0.0018	0.0131	0.0115	0.0237

7. EMPIRICAL EVIDENCE ON CHANGES IN RELATIVE RISK OF STOCKS

In Chapter V of this study, the behavior of relative risk of stocks of the firms which changed their methods of accounting for inventory valuation from FIFO to LIFO (Group A) and from LIFO to FIFO (Group B) has been examined. The average of ordinary least square estimates of relative risk of Group A firms was "significantly" higher during the post-change years as compared to the pre-change years. For Group B firms on the other hand, the average relative risk after the accounting change, was lower than the average risk before the accounting change. A χ^2 test on the distributions of estimated relative risk before and after the change confirmed a significant rightward shift in the relative risk of Group A firms. However, as discussed in Chapter V, ordinary least square estimates of standard error of estimated coefficients, understate the actual standard error in the presence of instability of coefficients. Therefore the significance of t-tests, on which the results of Chapter V are based, is overstated.

In the earlier sections of this chapter, procedures for estimating the degree of instability in the relative risk of firms and for testing hypotheses about it, have been presented and analyzed. Power functions for such tests have also been given. In the remaining parts of this section, these procedures are applied to the stock price data of the firms which made the accounting changes.

HYPOTHESIS TESTING

In Section 5, two procedures for testing hypotheses about variance of the slope coefficient of the linear model (5), have been

presented. In the first procedure, it is assumed that the slope coefficient is serially independent and it can be applied when no serial correlation is present or when its magnitude is unknown. When serial correlation is present, it has been shown that for the purpose of hypothesis testing, this procedure is not inferior to the second procedure in which the serial correlation coefficient is assumed to be known. Since prior estimates of serial correlation are not available, the first procedure is used in testing the following hypotheses about market model (1) which has been earlier defined as:

$$(1) \quad R_t = \beta_1 + \beta_{2t} R_{mt} + \varepsilon_t \quad (t = 1, \dots, T)$$

Null hypothesis H_0 : Variance of relative risk β_{2t} is zero.

Alternative hypothesis H_1 : Variance of relative risk β_{2t} is greater than zero.

For each firm's stock, ratio \hat{t}^* as defined in equation (16) is computed over four different segments of time series data. As detailed in Chapter III, there are a maximum of 126 firms in Group A and 26 firms in Group B. The four time segments over which tests are conducted are:

- (a) One hundred and twenty month period-- 60 months before and 60 months after the date of accounting change. The minimum data requirement was 30 which was satisfied by all 155 firms.
- (b) Fifty month period-- 25 months before and 25 months after the date of accounting change. Out of a total of 155 firms, only 137 had at least 30 observations during this period. This period is called Time Segment 1.

(c) Fifty month period, immediately preceding the date of accounting change and which is called Time Segment 2. Out of 155 firms only 135 had at least 30 observations available in this period and which were included in the sample.

(d) Fifty month period, immediately following the date of accounting change and which is called Time Segment 3. Out of 155 firms only 151 had at least 30 observations available in this period and which were included in the sample.

Summary statistics for \bar{t}^* computed for these firms over the four time segments are shown in Table VI.5. For 120 months around the date of accounting change, 114 of 155 or 73.5 % stocks had positive t-ratios. Had the relative risk of these firms been stable during this ten-year period, only 77.5 or 50 % of the t-ratios would have been expected to be positive. The binomial probability that 114 or more out of 155 trials will be positive when there is equal probability of obtaining positive and negative numbers is very close to zero. This means that if the null hypothesis of stable relative risk is true, the chances of observing as many as 114 positive t-statistics out of 155 is really quite small. Therefore it can be inferred with a high degree of confidence that the relative risk of these stocks over the ten year period around the date of accounting change was not stable.

The cross sectional mean, median and standard deviation of \bar{t}^* for 155 stocks are 0.714, 0.567 and 1.052 respectively. Since $\bar{\alpha}^*$ is an unbiased estimate of α (see equation (16)), the expected value of the sampling mean of \bar{t}^* is zero under the null hypothesis. The probability of mean \bar{t}^* being as high as 0.714 or higher by chance, under the null

Table VI. 5

Summary Statistics for the Test of Stability of Relative Risk of Stocks

Segment of Time Series Data Used

Statistic	Time Segment		
	1 60 months before and 60 months after change	2 25 months before and 25 months after change	3 50 months before the change
1. Mean of \bar{t} -- \bar{t}	0.714	0.409	0.823
2. Probability of \bar{t} exceeding observed value in row 1 under the null hypothesis	0.000	0.000	0.000
3. Median of t -- t_{median}	0.567	0.319	0.709
4. Standard Deviation of t	1.052	0.958	1.311
5. Relative Frequency of $t > 0$	0.74	0.62	0.69
6. Binomial Probability of Relative Frequency (row 5)	0.0000	0.0024	0.0000
7. Relative Frequency of $t > 1.645$	0.193	0.139	0.232
8. Sample Size	155	137	151

hypothesis is very close to zero. This provides further support for the rejection of the null hypothesis.

On an individual level, 30 out of 155 or 19.3 % stocks have t^* greater than 1.645 and the null hypothesis for these stocks can be rejected at about 5 % level of significance. It may be noted that if the null hypothesis was true, only about 8 out of 155 stocks will have t^* higher than 1.645.

Columns 2, 3 and 4 of Table VI.5 give statistics for similar analysis over three different segments of data of 50 months. All these results are qualitatively quite similar to those discussed above and strongly reject the null hypothesis that risk of the stocks under investigation was stable over the years surrounding the accounting changes.

Since the evidence on the instability of relative risk appears to be quite strong, the next step is to estimate the variance of the relative risk of these stocks. As has been noted in Section 5, estimates of slope variance are strongly dependent on the degree of serial correlation present in the slope. An attempt will be made to estimate simultaneously both the variance and the serial correlation of the slope with the help of actual results given in Table VI.5 and the Monte Carlo results given in Table VI.4. The procedure adopted here is somewhat informal and has limited accuracy because the Monte Carlo results are available for only a few discrete values of slope variance (α_2) and serial correlation (ρ) parameters. However, this method can be justified because both these parameters are unknown and a wrong assumption can result in a serious error in the estimation of the other.

A priori arguments given in Section 6 and the work done by Fisher (1970) and Bogue (1972) indicate that the value of ρ should be quite high-- somewhere between 0.9 and 1.

Some sampling statistics for t^* (Procedure 1, Section 5) estimated for various stocks from 50 months of actual data have been given in Table VI.5.

Monte Carlo results from the application of Procedure 1 to fifty observations of comparable data are given in Table VI.4. Part a, b and c of Table VI.4 will be examined to see which combinations of slope variance α_2 and serial correlation coefficient ρ are likely to have generated the results given in Table VI.5.

The likely cells of Table VI.4 from which the entries in rows 1,3 and 7 of Table VI.5 could come are shown in Table VI.6. The frequencies of the likely combinations of α_2 and ρ are summarized in Part d of Table VI.6. The most likely combinations are:

1. $\alpha_2 = 0.0625$ $\rho = 0.95$
2. $\alpha_2 = 0.25$ $\rho = 0.995$
3. $\alpha_2 = 0.25$ $\rho = 0.99$

in that order. There is, of course, considerable dispersion but this analysis does give a fair idea of the "ball park" figures for slope variance and serial correlation. Apparently a high degree of serial correlation in the range 0.95 to 1 exists in the random slope coefficients. Given a value of serial correlation ρ in this range, the slope variance α_2 of each stock can be estimated by Procedure 2 defined in Section 5.

Table VI. 6

Estimation of Slope Variance (α_2) and Serial Correlation Coefficient (ρ)

Part (a)

Relative Frequency of $t > 1.645$ from actual data

Likely combinations (α_2, ρ) from Table VI.4(a) with comparable relative frequency of rejection of null hypothesis

Time Segment	1	2	3
	0.14	0.10	0.23
	(0.0625, 0.95)	(0.01, 0.90)	(0.0625, 0.707)
	(0.25, 0.99)	(0.01, 0.95)	(0.25, 0.99)
	(0.25, 0.995)	(0.0625, 0.95)	(0.5675, 0.99)
	(0.5675, 0.995)	(0.25, 0.995)	(1.0, 0.995)

Part (b)

Sampling Mean of t

Likely combinations of (α_2, ρ) from Table VI.4(b) with comparable sampling means

	0.41	0.29	0.82
	(0.0625, 0.90)	(0.0625, 0.95)	(0.0625, 0.707)
	(0.0625, 0.95)	(0.25, 0.995)	(0.5675, 0.99)
			(1.0, 0.995)

Part (c)

Sampling Median of t

Likely combinations of (α_2, ρ) from Table VI.4(c) with comparable sampling medians

	0.52	0.21	0.71
	(0.625, 0.90)	(0.01, 0.9)	(0.0, 0.0625)
	(0.25, 0.99)	(0.01, 0.93)	(0.0625, 0.707)
		(0.0625, 0.95)	(0.5675, 0.99)
		(0.25, 0.995)	

Part (d)

$\rho \backslash \alpha_2$	0.0	0.01	0.0625	0.25	0.5675	1.0	6.25
0.0			1				
0.707			3				
0.90		2	2				
0.95		2	5				
0.99				3	3		
0.995				4	1	2	

8. SUMMARY

In this chapter, two random coefficient versions of market model which allow for changes in relative risk of firms, have been analyzed. Two procedures have been defined to test hypotheses about the stability of relative risk. One procedure assumes that the slope coefficient is independently distributed and the other assumes that the slope is an autoregressive random variable and its serial correlation coefficient is known. Monte Carlo experiments have been conducted to examine the power functions of these procedures under varying degrees of slope variance and serial correlation. While the presence of a high degree of serial correlation considerably weakens the power of the test, information about the value of this parameter (ρ) does not increase the power of the test.

The data for the stock prices of firms which made the accounting changes discussed in Chapter III, are tested for the presence of instability in their relative risk during the years surrounding the date of accounting change. Evidence rejects the null hypothesis that the relative risk of these stocks was constant during this period.

An attempt has been made to identify the degree of serial correlation and variance present in the relative risk of these stocks. The value of serial correlation appears to be quite high in the range 0.95 to 1.0. The variance of risk seems to lie in the range 0.06 to 0.25 which corresponds to the range 0.25 to 0.5 for standard deviation, which is quite a large variation in relative risk. This estimation procedure, however, is rather informal and only provides a rough

approximation for the group of stocks under study. The value of these parameters, specially variance (α_2) for the individual stocks in the group may be quite different.

The purpose of this chapter has been to test and demonstrate the instability of relative risk of the firms which changed their accounting procedures.¹² In the next chapter, procedures for estimating the time path of risk are presented and applied to the stock price data in order to examine the relationship between accounting and risk changes.

¹²For the application of these procedures to the stock price data of the New York Stock Exchange, see Bogue and Sunder (1973).

CHAPTER VII

CHANGES IN ACCOUNTING AND RELATIVE RISK OF STOCKS (II)

1. INTRODUCTION

The purpose of this chapter is to estimate the time path of the relative risk of firms and to use these estimates for the study of the relationship between accounting and risk changes. Possible reasons for the existence of such a relationship have been given in Chapter V.2. Preliminary evidence presented in Chapter V indicated that the relative risk of the firms which switched to LIFO increased after the change and decreased for the firms which changed from LIFO to FIFO. The evidence in Chapter V is considered preliminary because ordinary least square estimates of risk have been used under the assumption that this parameter remains stable within the periods before and after the accounting change. The analysis given in Chapter VI indicates that this is not a valid assumption. Relative risk of the firms changed not only between the periods before and after the accounting change but also within these periods. Therefore, it is necessary that procedures which take the instability of risk into account be used to estimate the time path of the risk of firms. Such estimates would provide a measure of association between accounting and risk changes. They would also be used to abstract the effect of risk changes from the measurement of association between accounting and price changes.

In the next section, various approaches to estimation and prediction of relative risk in a changing environment are reviewed.

These techniques are taken from econometrics and engineering literature and are not yet well known to accounting and finance researchers. In Section 3, one of the procedures is used to estimate the time path of relative risk and the abnormal performance of stocks of those firms which made the accounting changes. The results are compared with those obtained in Chapters IV and V. The chapter is summarized in Section 4.

2. ESTIMATION OF RELATIVE RISK IN A CHANGING ENVIRONMENT

RANDOM WALK AS A DESCRIPTION OF THE BEHAVIOR OF RISK

Relative risk of a firm is determined by the nature of its assets, business environment and future prospects. Since these factors do not change very frequently, the risk of a firm measured at regular intervals is likely to be highly autocorrelated.

Bogue (1972) proposed a theory for the behavior of relative risk based on continual depletion of old assets and the addition of new assets to the firm. He theorized a first order autoregressive process for the risk parameter β of which random walk is a special case. If β_t is relative risk in period t , β_{t-1} is relative risk in period $t-1$, ρ is the autocorrelation coefficient and u_t is an identically and independently distributed random variable, the first order autoregressive process is characterised by (1)

$$(1) \quad \beta_t = \rho \beta_{t-1} + u_t$$

If autoregressive constant ρ is unity, this process is reduced to a random walk.

$$(2) \quad \beta_t = \beta_{t-1} + u_t$$

Evidence presented in Chapter VI indicates that if the relative risk of firms is assumed to follow the process defined by (1), then the autocorrelation coefficient is, indeed, quite close to unity. Fisher (1970) and Bogue (1972) provide further empirical support to the view that the behavior of risk can be closely approximated by a random walk. Therefore the random walk model (2) of relative risk is used in the remaining sections of this chapter.

SPECIFICATION

This subsection presents a brief review of the work in engineering and econometrics literature which is directly applicable to the problem of estimating relative risk of firms in a changing environment. The market model is written in the following form:

$$(3) \quad y_t = \beta_{1t} + \beta_{2t} x_t \quad (t = 1, \dots, T)$$

where y_t , the return on a stock in period t is the dependent variable;

β_{1t} is the random intercept in period t ; β_{2t} is the relative risk in period t ; and x_t is the return on the market index, the independent variable. There are T observations indexed by $(t = 1, \dots, T)$.

Conventionally, an estimate of the coefficient β_{2t} is called a smoothed estimate, a current or filtered estimate or a forecast depending on whether t is less than, equal to or greater than T . For the purpose of tracing the time path of relative risk in this study, the primary concern is with the smoothed estimates. For example, to make an estimate

of the risk of a firm in January 1950, there is no reason why data from the months before as well as after this date (which is now available) should not be used to gain efficiency of estimation.

The problem of tracing the path of relative risk of firms is analogous to the engineering problem of tracing the path of a rocket using radar signals. Since no single signal is completely accurate and the rocket may change its direction at any time due to a large number of factors, its position is continually recalculated from the past and current radar signals. In such a system, later signals are given greater weight than the earlier signals. The ordinary least square procedure is comparable to a system in which all signals are given equal weight irrespective of the time they are received. In order to obtain optimal estimates of relative risk, a weighting scheme for the observations must be devised. A frequently used criterion of optimality is minimizing the variance of estimate.

Exponential smoothing is a scheme in which weights of observations decrease exponentially with the distance from the point of estimation. This procedure has been shown to be optimal for very large (theoretically infinite) number of observations.¹ For finite number of observations, exponential smoothing is only a good approximation. Ad hoc procedures for applying it to finite samples are given by Holt, Modigliani, Muth and Simon (1963) and Wade (1967).

In considering the current estimation problem for a general

¹See Muth (1960)

discrete dynamic system, Kalman (1960) provided an optimal weighting scheme (filtering scheme) for a finite number of observations.²

Rosenberg (1968) extended Kalman's results to smoothing and forecasting.

Fisher (1970, 1971) applied these results to the market model. Fisher assumes that: (a) the intercept term β_{1t} in the market model (3) is always zero and (b) the relative risk parameter β_{2t} follows a random walk,

$$(4) \quad \beta_{2t} = \beta_{2,t-1} + u_t$$

where u_t is an identically and independently distributed random variable with zero mean. Under these two assumptions, he obtains the minimum variance linear unbiased estimate b_t of β_{2t} :

$$(5) \quad b_t = \frac{\sum_{j=1}^t \phi_j x_j y_j}{\sum_{j=1}^t \phi_j x_j^2}$$

²The problem considered by Kalman can be described as follows: Observable variables y_t and $(x_{0t}, x_{1t}, \dots, x_{nt})$ are related by,

$$y_t = \beta_{0t} x_{0t} + \beta_{1t} x_{1t} + \dots + \beta_{nt} x_{nt}$$

or in vector notation

$$\begin{array}{ccc} y_t & = & x_t \beta \\ (px1) & & (pxn)(nx1) \end{array}$$

Parameter vector β follows the lineardynamic model

$$\beta(t+1) = \phi(t+1; t) \beta(t) + u(t)$$

where $u(t)$ is an independent gaussian n -vector with zero mean, $\beta(t)$ is a n -vector, $y(t)$ is a p -vector, and $\phi(t+1; t)$ is the (nxn) transition matrix.

$$(6) \quad \phi_{t+1} = \phi_t + \frac{\omega^2}{\sigma_u^2} \sum_{h=1}^t x_h^2 \phi_h$$

where ω^2 is the step variance of changes in relative risk and σ_u^2 is the variance of the intercept term β_{1t} in the market model (3). ϕ_t 's are the weights assigned to individual observations.³ The procedure for applying this scheme is to put ϕ_1 (or ϕ_T) equal to any positive number, say 1 and work forward (or backward) with the observations x_t and the variance ratio ($\frac{\omega^2}{\sigma_u^2}$). Fisher does not give a procedure for estimating ($\frac{\omega^2}{\sigma_u^2}$). He assumes that this ratio is the same for all stocks and conducts estimation with several assumed values of this ratio.

In contrast to Kalman, Rosenberg and Fisher's work, Cooley and Prescott (1973) view this problem in the framework of a regression model.⁴ Their model is more general than those considered above in the sense that it allows for both permanent and transitory changes in parameters of the linear model. Their formulation is more suitable for the problem on hand and is discussed next.

Rewrite market model (3) as

$$(7) \quad y_t = x_t' \beta_t \quad (t = 1, \dots, T)$$

³It might be interesting to compare (5) with the corresponding OLS estimator under similar set of assumptions

$$b_t(\text{OLS}) = \frac{\sum_{j=1}^t x_j y_j}{\sum_{j=1}^t x_j^2}$$

which implies $\phi_1 = \phi_2 = \dots = \phi_T$

⁴A good reference which shows the relationship and equivalence of recursive and regression approaches to the problem is Duncan and Horn (1972).

where x_t is a two component vector of explanatory variables, the first element being 1 and the second being the return on the market factor.

β_t is a two component vector of coefficients β_{1t} and β_{2t} in period t . The first component represents the random intercept and the second is the risk coefficient (relative risk) of the market model. Vector β_t can change from one period to another. Changes can either be transitory, which last only for a single period, or can be permanent which persist into the future periods once they have occurred. Denote the two-component vector of transient parameter change in period t by u_t . Then the realized value of the parameter in period t can be written as the sum of a permanent component w_t and the transient change u_t .

$$(8) \quad \beta_t = w_t + u_t \quad (t = 1, \dots, T)$$

Permanent component w_t of the parameter vector differs from the permanent component w_{t-1} in period $t-1$ by the permanent change vector v_t :

$$(9) \quad w_t = w_{t-1} + v_t \quad (t = 2, \dots, T)$$

u_t and v_t are assumed to have a bi-variate normal distribution. It is also assumed that each vector has the same distribution in each period, and is intertemporally independent of itself and of each other. Let $\sum^* u$ and $\sum^* v$ be the covariance matrices of u_t and v_t respectively.

Then,

$$(10) \quad u_t \sim N_2(\underline{0}, \sum^* u)$$

$$(11) \quad v_t \sim N_2(\underline{0}, \sum^* v)$$

$$(12) \quad E(u_t u_s') = E(v_t v_s') = 0 \quad \text{for } t \neq s$$

$$E(u_t v_t') = 0 \quad \text{for all } t$$

Since the covariances matrices $\sum^* u$ and $\sum^* v$ are not independently identifiable, Cooley and Prescott suggest the following reparametrization:

$$(13) \quad \sum^* u \equiv (1 - \gamma) \sigma^2 \sum u$$

$$\sum^* v \equiv \gamma \sigma^2 \sum v$$

where $\sum u$ and $\sum v$ are known up to a scale factor. In other words, the degree of instability in each parameter relative to the other has to be prespecified. For the market model, an appropriate structure for these matrices is suggested in the next paragraph.

σ^2 is the scaling parameter to be estimated.

γ is a parameter which has a value between 0 and 1 and defines the partition of the total variance between permanent and transient changes.

This reparametrization will be clear from the following discussion for its application to the market model. Rewrite $\sum u$ and $\sum v$ as,

$$(14) \quad \sum u = \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix}$$

$$\sum v = \begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix}$$

Since these matrices are defined only up to a scale factor, it does not matter if all their elements are divided or multiplied by the same non-zero number. Corresponding estimates of σ^2 and γ from the procedure defined later will be adjusted accordingly. s_{11} represents the transient variance of the intercept term and corresponds to the error term in the ordinary regression model. s_{11} can be arbitrarily set equal to one and the value of other elements of the matrix can be defined in relation to it. s_{22} represents the variance of transient changes in the slope parameter. Only permanent changes in this parameter shall be considered since this assumption obviates the necessity of having to specify the comparative magnitude of transitory variance between the intercept and the slope parameter. Off diagonal terms s_{12} and s_{21} also will be zero when s_{22} is zero. This gives, up to a scale factor,

$$(15) \quad \Sigma_u = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}.$$

r_{11} represents the variance of permanent changes in the intercept term of the market model. Since the intercept of the model is theoretically zero, there is no need to allow for permanent changes in the intercept, and r_{11} can be set equal to zero, which implies that the covariance terms r_{12} and r_{21} are also zero. This matrix can be normalized by setting r_{22} , the variance of permanent changes in the slope parameter equal to one.

Thus up to a scale factor,

$$(16) \quad \Sigma_v = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$$

and covariance matrices of u_t and v_t from (13) can be written as,

$$(17) \quad \text{Cov} (u_t) = (1 - \gamma) \sigma^2 \Sigma_u = (1 - \gamma) \sigma^2 \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$$

$$(18) \quad \text{Cov} (v_t) = \gamma \sigma^2 \Sigma_v = \gamma \sigma^2 \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$$

In other words, the variance of transient changes in the intercept is $(1 - \gamma) \sigma^2$ and the variance of the permanent step changes in the slope is $\gamma \sigma^2$.⁵ Since both parameters σ^2 and γ as well as the linear coefficients β_{1t} and β_{2t} are estimated by the procedure described next, there is no need to prespecify how much variance arises from the slope changes.

ESTIMATION

Parameter levels in a random walk process are non-stationary, and likelihood functions for them cannot be specified. But a likelihood function conditional on some specific realization at some point in time, can be defined and the value of the parameter at that point can be

⁵Fisher (1970) parametrizes the problem somewhat differently. In his formulation K is the ratio of the step variance of the slope coefficient to the intercept variance:

$$K = \frac{\gamma \sigma^2}{(1-\gamma) \sigma^2} = \frac{\gamma}{1-\gamma}$$

or
$$\gamma = K / (1 + K)$$

Thus γ and K have a one to one relationship. Fisher, however, does not propose a procedure for the estimation of K .

estimated. Suppose a total of T observations ($t = 1, \dots, T$) are available for estimation, and the realized values of the parameters for $t = t^*$ are to be estimated. Parameter values β_t at any point in time can be written in terms of the parameter vector at the time t^* and the error terms from (8) and (9):

$$(19) \quad \beta_t = \begin{cases} w_t^* - \sum_{s=t+1}^{t^*} v_s + u_t & \text{for } 1 \leq t < t^* \\ w_t^* + \sum_{s=t+1}^{t^*} v_s + u_t & \text{for } t^* < t \leq T \end{cases}$$

Since w_t^* is the parameter of interest for estimation, let

$$(20) \quad \beta = w_t^*$$

Model (7) can now be rewritten in terms of β and the error term μ_t

$$(21) \quad y_t = x_t' \beta + \mu_t$$

where

$$\mu_t = \begin{cases} x_t' u_t - x_t' \sum_{s=t+1}^{t^*} v_s & \text{for } 1 \leq t < t^* \\ x_t' u_t + x_t' \sum_{s=t+1}^{t^*} v_s & \text{for } t^* < t \leq T \end{cases}$$

Since u_t and v_t are normally distributed with mean zero and covariance $\sum^* u$ and $\sum_{t^*}^* v$, it can be shown that μ_t is also normally distributed with mean zero and the covariance matrix,

$$(22) \quad \text{Cov}(\mu) = \sigma^2 (1-\gamma) R + \gamma Q = \sigma^2 \Omega(\gamma)$$

where R is a $(T \times T)$ diagonal matrix with

$$(23) \quad r_{ii} = x_i' \sum_u x_i$$

$$\text{since } \sum_u = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} \text{ and the first element of } x_i \text{ is 1,}$$

$$R = I_T$$

and ij^{th} element of matrix Q is given by,

$$(24) \quad q_{ij} = \begin{cases} \min(|t-i|, |t-j|) x_i' \sum_v x_j & \text{for } \begin{cases} i \text{ and } j < t \\ i \text{ and } j > t \end{cases} \\ 0 & \text{for } \begin{cases} i \leq t \text{ and } j \geq t \\ i \geq t \text{ and } j \leq t \end{cases} \end{cases}$$

then the full model can be written as

$$(25) \quad y = X\beta + \mu$$

where y is a $(T \times 1)$ vector of dependent variable

X is a $(T \times 2)$ matrix of independent variables

β is a (2×1) vector of parameter values in period t as defined in (20)

μ is a $(T \times 1)$ vector of error terms as defined above

y is distributed normally with mean $X\beta$ and covariance $\sigma^2 \Omega(\gamma)$.

When γ is known, the estimate of β can be obtained by applying generalized least squares to (25) since the covariance matrix is a function of X and γ alone. In the market model for stocks, the value of γ for each stock is not known and has to be estimated. Cooley and

Prescott propose both maximum likelihood and bayesian estimators for γ , σ^2 and β . The bayesian procedure is used here for the estimation of the expected value of γ for each stock. This estimate is then used in Aitken's generalized least square procedure to estimate β .

Generalized least square estimate B of β conditional on γ is,

$$(26) \quad B(\gamma) = (X' \Omega^{-1}(\gamma) X)^{-1} X' \Omega^{-1}(\gamma) y$$

The estimate of σ^2 conditional on $B(\gamma)$ and γ is,

$$(27) \quad s^2(\gamma) = \frac{1}{T} (y - X B(\gamma))' \Omega^{-1}(\gamma) (y - X B(\gamma))$$

if the prior density of γ is $f(\cdot)$, the posterior density for γ is given by

$$(28) \quad p(\gamma; y) \propto f(\cdot) |\Omega(\gamma)|^{-\frac{1}{2}} |(X' \Omega^{-1}(\gamma) X)^{-1}|^{\frac{1}{2}} (T s^2(\gamma))^{-(T-2)/2}$$

The expected value of the posterior distribution of γ is obtained by numerical integration. This value is then used in (26) and (27) to estimate the value β of linear coefficients at time t^* and σ^2 by $B(\gamma)$ and $s^2(\gamma)$ respectively.

In the next section, results from the estimation of risk of stocks around the date of accounting changes from the procedure defined above are presented.

two year period surrounding such changes are presented. The analytical procedure used is quite similar to the one used in Chapter IV, except that the relative risk of stocks is estimated not from ordinary least square regression but from the adaptive regression procedure defined in the previous section of this chapter. In Chapter IV, the assumption was that the risk of stocks is stable and some preliminary evidence was presented in Chapter V to question the propriety and adequacy of this assumption. In Chapter VI, some statistical testing of the assumption was conducted and it was found that the stable risk framework is not adequate. In Section 2 of this chapter, an estimation procedure which is optimal for the estimation of risk under the assumption that it follows a random walk, has been presented. This procedure is used to estimate the time path of the relative risk of firms during the 24 months surrounding the date of accounting change. These estimates of risk coefficients are averaged cross sectionally to detect their relationship, if any, with the accounting changes. In addition, the residual analysis of Chapter IV is repeated with the difference that the residuals are estimated from the new estimates of relative risk. Abnormal price changes measured in Chapter IV represent the combined effects of risk changes and transient price changes. The results given in this section can be viewed as a decomposition of the earlier results into two components.

The procedure used for the empirical analysis given in this section can be described in the following steps:

1. A prior probability density function for Y is assumed.

Since no information is available to distinguish one stock from

another in this respect, this density is identical for all stocks. $\gamma = 0$ implies that all the variance arises from the intercept or the additive disturbance term in the market model and the slope parameter representing the relative risk of the firm is constant. This essentially means that ordinary least square regression is adequate for estimation since the relative risk parameter is stable over time. At the other extreme, $\gamma = 1$ implies that all the variance arises from the variation of the slope, and the additive disturbance term for all observations is identically equal to zero. A prior probability density function should represent the researcher's preconception about the chances of the occurrence of the values of γ in the 0 to 1 range. From the results given in Sunder (1973a, Chapter VI), γ is much more likely to be close to zero than to one because the null hypothesis that the risk of the firms during the months surrounding the accounting change was stable, was rejected for only 20 % of the stocks tested. Therefore a declining ramp prior density function defined by (29) is used.

$$(29) \quad f(\gamma) = 2(1 - \gamma) \quad \text{for } 0 \leq \gamma \leq 1$$

This density function has the value 2 at $\gamma = 0$ and declines uniformly to 0 at $\gamma = 1$. For each stock j , steps 2 through 4 are repeated.

2. The posterior density of γ is estimated from equation (28). Up to a total of 75 months of data from month -37 to 37 are used for this estimation. The month of accounting change is designated

as month 0 and the data for this month are included for estimation. The first moment of the posterior distribution of γ is calculated. This statistic $\hat{\gamma}_j$ is used as an estimate of γ for stock j . The stocks for which a minimum of 25 observations in the range specified above are not available are excluded from this analysis. Out of 155, 133 stocks are analyzed.

3. The intercept and the risk coefficients of the market model, and parameter σ^2 are estimated for each of the 24 months from month -11 to 12 by using estimate $\hat{\gamma}_j$ of γ in equations (26) and (27). A maximum of 41 months and a minimum of 25 months of data are used to estimate the relative risk for each month. For example, to estimate the risk in month -11, t^* is put equal to -11 and the data from the months -31 to month 9 are used. Similarly for the estimation of risk in month 12, the data from the month -8 to 32 are used. The purpose of using this moving series scheme is to maximize the precision of estimates from a given number (41) of observations since most precise estimates are obtained at the midpoint of the time series. The estimates obtained from using all the data from the month -31 to 32 for estimation of risk in each month would have been more precise but would have required much more computer time. Twenty four estimates of relative risk for each stock (b_{jt} , $t = -11, \dots, 12$) are stored.

4. For each of the 24 months surrounding the accounting change, the regression residual is calculated using the estimated

coefficients of the market model for the respective months.

Twenty four residuals that are thus obtained (\hat{u}_{jt} , $t = -11, \dots, 12$) are also stored in memory.

5. After steps 2 through 4 are completed for all stocks, the cross sectional mean of the relative risk of a group of stocks is calculated for each of the 24 months. If there are N stocks in the group being analyzed, the average relative risk of the stocks in this group in month t is denoted by \bar{b}_t :

$$(30) \quad \bar{b}_t = \frac{1}{N} \sum_{j=1}^N b_{jt} \quad (t = -11, \dots, 12)$$

6. The cross sectional mean of residuals for the group in period t is \bar{u}_t ,

$$(31) \quad \bar{u}_t = \frac{1}{N} \sum_{j=1}^N \hat{u}_{jt} \quad (t = -11, \dots, 12)$$

7. Cumulative abnormal residual U_t for the group in period t is defined as

$$(32) \quad U_t = \sum_{s=-11}^t \bar{u}_s \quad (t = -11, \dots, 12)$$

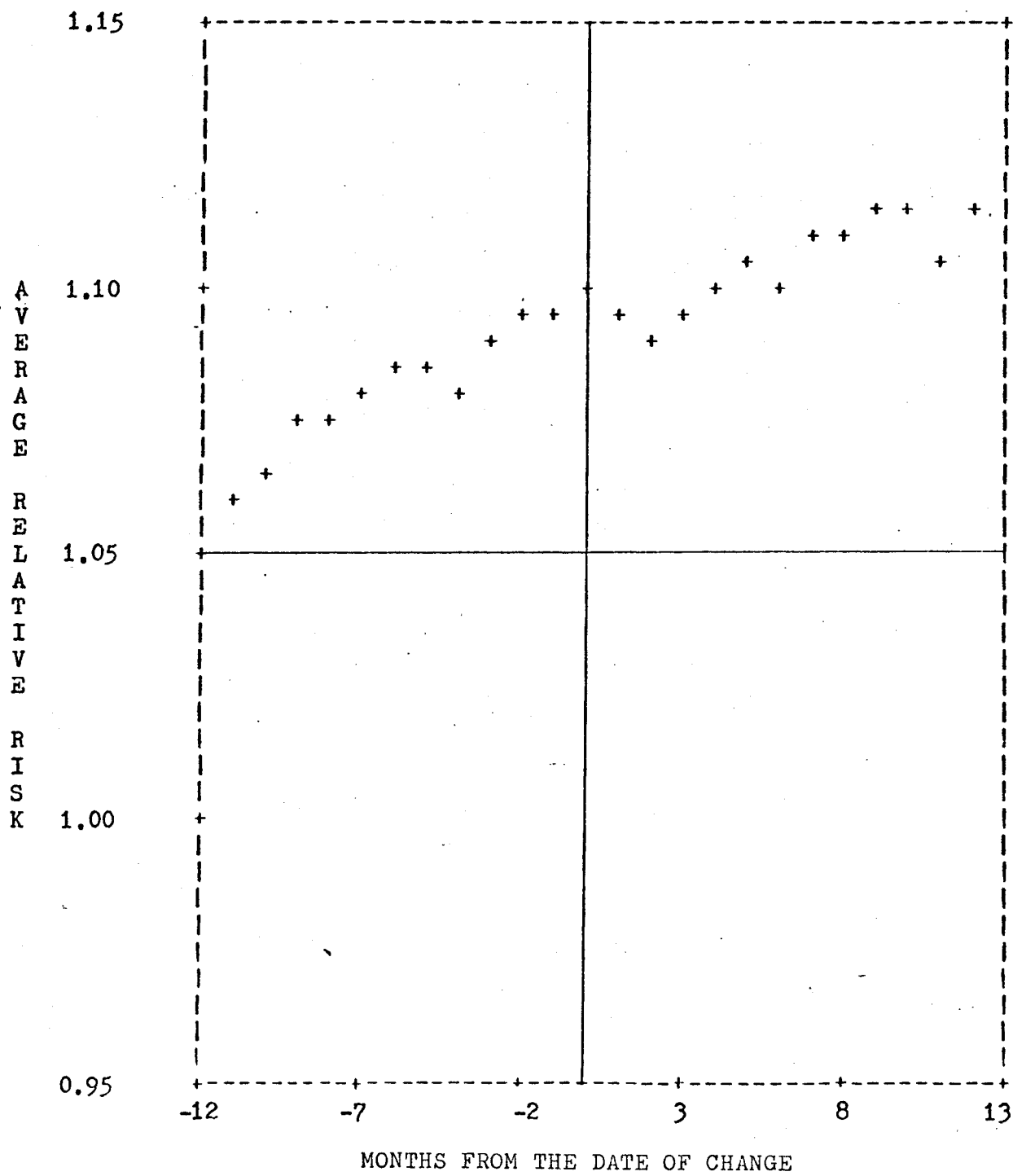
RESULTS

The average relative risk of several groups and subgroups of stocks for the 24 month period around the date of accounting change is shown in Table 1. The first column of the table gives the average risk of 118 firms of Group A which switched over to LIFO in month 0.

Table 1.

Average Relative Risk of Stocks in 24 Months
Around the Date of Accounting Change

Sample Size	(1) Relative Change Risk Group A		(2) Relative Change Risk Group A Without Steel		(3) Relative Change Risk Group A Steel Only		(4) Relative Change Risk Group B	
	118		96		22		21	
Month								
-11	1.058		0.974		1.418		1.090	
-10	1.064	+0.006	0.974	+0.000	1.445	+0.027	1.106	+0.016
-9	1.073	+0.009	0.979	+0.005	1.473	+0.028	1.098	-0.008
-8	1.076	+0.003	0.979	+0.000	1.487	+0.014	1.107	+0.009
-7	1.080	+0.004	0.986	+0.007	1.483	-0.004	1.106	-0.001
-6	1.085	+0.005	0.988	+0.002	1.503	+0.020	1.105	-0.001
-5	1.086	+0.001	0.987	-0.001	1.511	+0.008	1.111	+0.006
-4	1.082	-0.004	0.980	-0.007	1.518	+0.007	1.102	-0.009
-3	1.089	+0.007	0.985	+0.005	1.534	+0.016	1.087	-0.015
-2	1.095	+0.006	0.997	+0.012	1.514	-0.020	1.076	-0.011
-1	1.094	-0.001	0.993	-0.004	1.527	+0.013	1.070	-0.006
0	1.102	+0.008	1.000	+0.007	1.536	+0.009	1.065	-0.005
1	1.097	-0.005	0.992	-0.008	1.551	+0.015	1.054	-0.011
2	1.092	-0.005	0.988	-0.004	1.545	-0.006	1.066	+0.012
3	1.094	+0.002	0.990	+0.002	1.548	+0.003	1.061	-0.005
4	1.101	+0.003	0.997	+0.007	1.550	+0.002	1.058	-0.003
5	1.103	+0.002	1.001	+0.004	1.544	-0.006	1.028	-0.030
6	1.100	-0.003	0.998	-0.003	1.547	+0.003	1.095	+0.067
7	1.112	+0.012	1.011	+0.013	1.554	+0.007	1.007	-0.088
8	1.110	-0.002	1.009	-0.002	1.550	-0.004	1.021	+0.014
9	1.115	+0.005	1.016	+0.007	1.544	-0.006	1.040	+0.019
10	1.113	-0.002	1.023	+0.007	1.504	-0.040	1.012	-0.028
11	1.107	-0.006	1.015	-0.008	1.507	+0.003	1.023	+0.011
12	1.115	+0.008	1.026	+0.011	1.503	-0.004	1.032	+0.009

AVERAGE RELATIVE RISK FOR 24 MONTHS AROUND
THE DATE OF ACCOUNTING CHANGE

Group A

Figure 1.

By themselves, these results show only small changes in the relative risk. But considered with the results of Chapter V, they look quite significant because they confirm the earlier results which indicated that the average risk of these firms during the pre-change months was lower than in the post-change months. During the two years, the average risk of these firms increased by 5.4 % from 1.058 to 1.115. As can be seen from the plot of the time path of relative risk of this group in Figure VII.1, the increase in risk was the general trend for this group for the entire 24 month period, though 78 % of the total change occurred in the 12 months preceding the accounting change. This observed behavior of risk is consistent with the hypothesis discussed in Chapter V.2 that adoption of LIFO makes the value of the firms more sensitive to unanticipated price level changes and therefore, more risky.

Since the steel firms represented a disproportionately large part of this sample, (22 out of 118), steel and non-steel firms were analyzed separately. These results are also given in Table VII.2, and they generally support the remarks made above for the entire sample. The average relative risk of non-steel firms increased by 5.3 % while the average risk of the steel firms increased by 6 % during the 24 month period surrounding the date of accounting change.

For the 21 firms in Group B which made an accounting change from LIFO to FIFO, the average relative risk decreased by 5.3 % during the 24 month period around the date of accounting change. This observation also supports the hypothesis discussed in Chapter V.2 about the relationship between changes in accounting for inventory costing and risk changes.

The average abnormal price changes for each group of stocks, adjusted for relative risk and changes in relative risk are shown in Figure VII.2 through VII.5. These figures are comparable to the corresponding figures in Chapter IV which were obtained without making adjustments for the risk changes. Figure VII.2 gives the cumulative average abnormal residuals starting month -11 through month 12 for 118 firms which changed to LIFO. During the first 12 months, the average abnormal price change was 4.7 % resulting in a 24 month increase of 2.9 %. The increase of 4.7 % during the first 12 months is only a little smaller than the 5.3 % increase measured with the constant risk assumption in Chapter IV. The pattern of risk changes in Figure VII.2 also is quite similar to the pattern given in Figure IV.1.

The exclusion of steel firms from Group A (see Figure VII.3) reduces the abnormal price change during the first 12 months to 2.3 % and during the 24 months to 0.8 %. While these numbers can hardly be called significant by themselves, they are consistent with the price changes observed for Group A as a whole--abnormal price rise during the pre-change months followed by a smaller decrease in the post-change months.

The behavior of the price of steel stocks (see Figure VII.4) is also similar in nature but the price changes are much larger. The abnormal price rise for these stocks was 14.9 % during the 12 pre-change months followed by a 2.9 % decrease during the 12 post-change months. These results correspond closely to those obtained in Chapter IV under the constant risk assumption. However, the interpretation of these

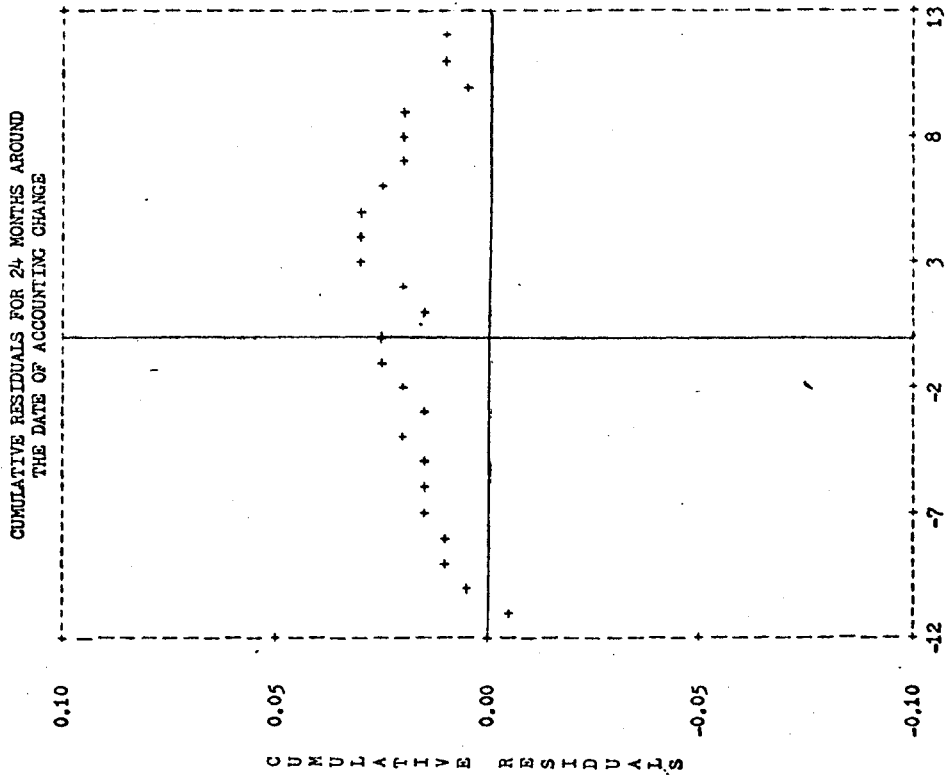


Figure 3.

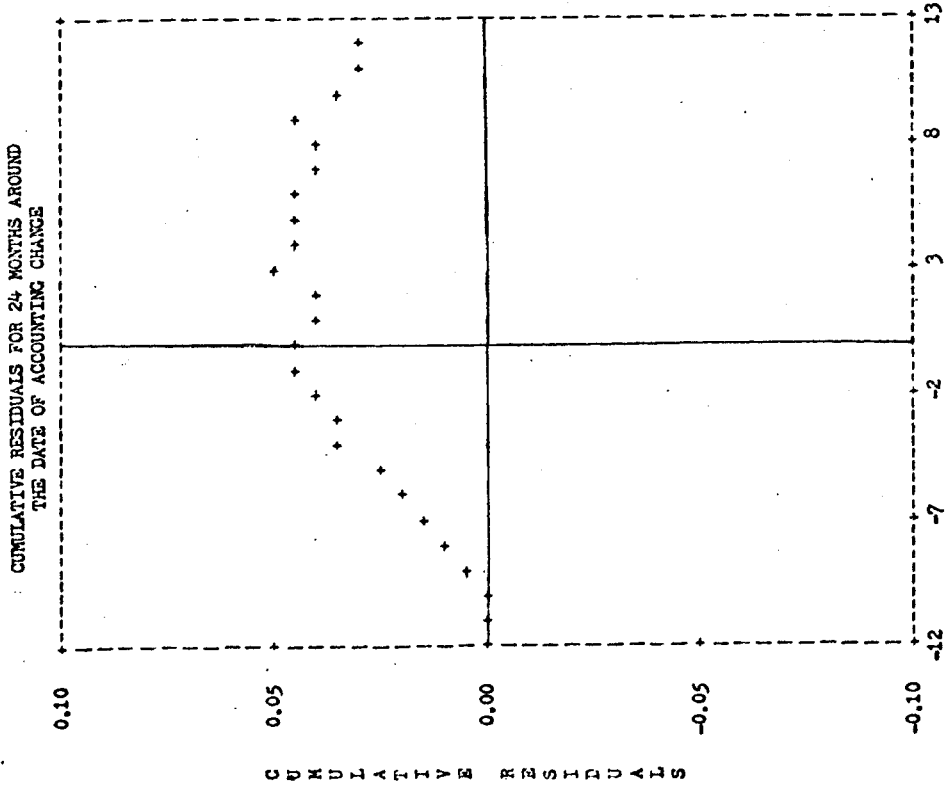


Figure 2.

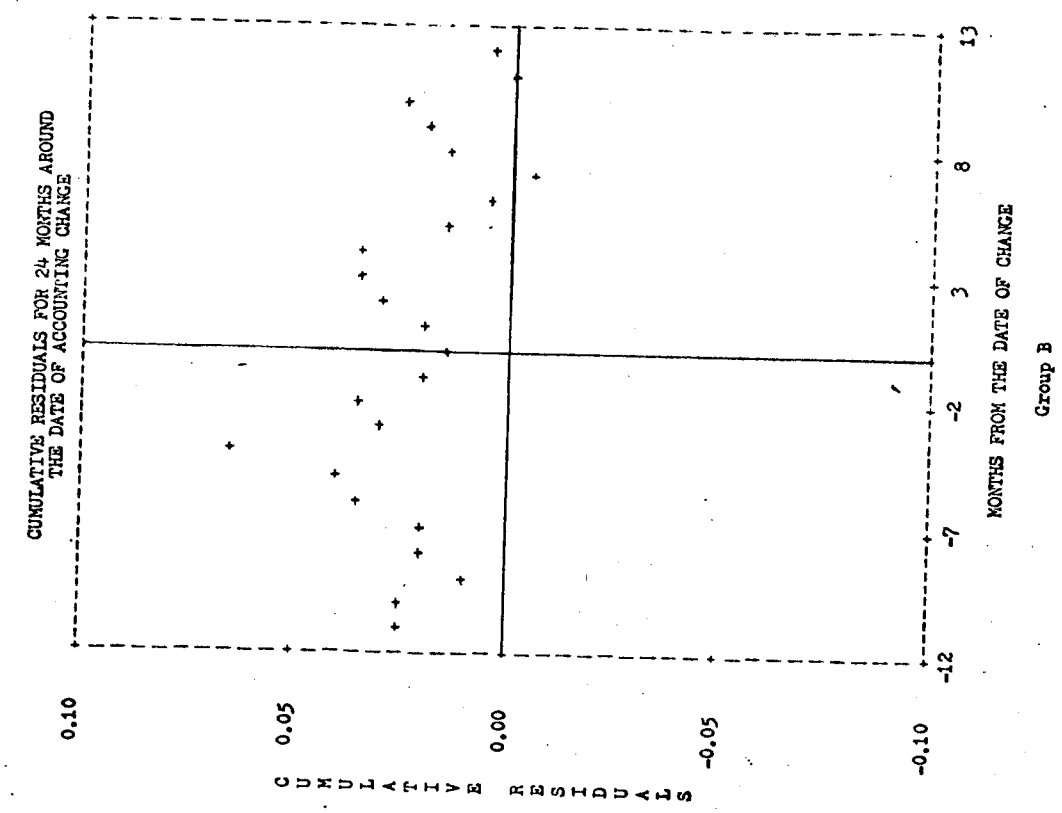


Figure 5.

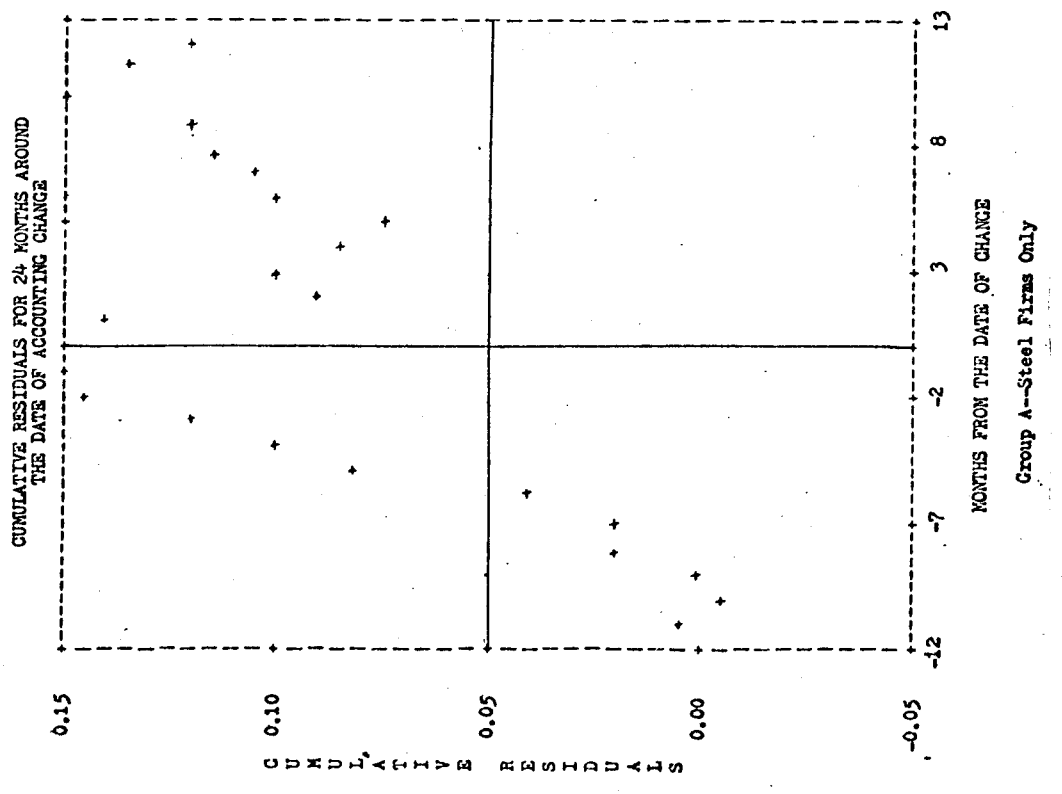


Figure 4.

results is difficult in light of the remarks made in Chapter IV.2 about the difficulty of extracting the industry effect in the presence of industry wide accounting changes.

The cumulative abnormal price changes for Group B given in Figure VII.5 have too much noise because the sample size is small. When compared with Figure IV.3 for abnormal price changes measured under the constant relative risk assumption, most of the abnormal decline in prices observed earlier appears to have been due to the failure of that procedure to account for the decrease in the relative risk of those firms. A slight downward drift in the price of these stocks remains. Nevertheless, it is clear that the price of these stocks did not increase as a result of the switch from LIFO to FIFO and the associated increase in the reported earnings. Industry-wise analysis of Group B was not conducted since this sample is already small and its sub-samples are unlikely to provide any further insights.

4. SUMMARY

In this chapter a model has been presented to estimate the relative risk of stocks in a changing environment. This estimation procedure has been applied to the stock price data of the firms which made a change in the method of costing their inventories. The time path of the relative risk of various groups of the sample firms has been estimated over the 24 month period surrounding the date of accounting change. This analysis indicated:

- (a) The relative risk of firms which changed to LIFO increased by 5.4 % during the 24 months.

(b) Exclusion of steel firms which constituted 19 % of the sample, did not change this result by a significant amount.

(c) The average relative risk of steel firms which made this accounting change also increased by 6 %.

(d) The average relative risk of the firms which changed their accounting method to FIFO decreased by 5.3 % during this period.

Using these estimates of relative risk, abnormal price change analysis has been performed on various groups of these firms.

This analysis indicated:

(a) Adjustment for changes in the relative risk caused only small changes to the measured abnormal performance because the observed changes in relative risk themselves were relatively small (about 5 %). The direction of changes in the estimated abnormal performance adjusted for risk was consistent with the direction predicted in Chapter V.

(b) For all firms in Group A, the average abnormal change in stock price was 4.7 % in the first year and -1.8 % in the second.

(c) For non-steel firms in Group A, the average abnormal change in price was 2.3 % in the first year and -1.5 % in the second.

(d) For steel firms in Group A, the average abnormal price change was 14.9 % in the first year and -2.9 % in the second.

(e) For Group B, these price changes were 1.6 % and -0.8 % respectively.

In the next chapter of this study, findings of all the chapters are summarized and interpreted. The limitations of this study and the perspective for future research in this area are also discussed.

CHAPTER VIII

SUMMARY AND CONCLUSION

1. SUMMARY OF RESULTS

In this final chapter, we will first summarize the results obtained in the previous chapters of this thesis. In the next section, these results will be interpreted from substantive and methodological standpoints and conclusions will be drawn. The last section will be devoted to a discussion of the limitations of this study and to the directions for further research on the role of financial accounting in capital markets.

The following paragraphs summarize the results obtained in Chapters I through VII of this thesis. Numbers in parantheses refer to the corresponding chapters and sections.

1. The intent of this thesis is to analyze the association between changes in accounting for financial reporting and investor behavior. It is hoped that such a study will be useful to the investors, managers and auditors and help in the development of standards of financial reporting. (I.1)

2. Accounting changes involving the adoption or abandonment of the LIFO method of inventory valuation have been selected for analysis in this study.

3. The approach of this thesis is to study the relationship between accounting changes and investment behavior at the market level in terms of price and relative risk of stocks. (I.2)

4. Empirical studies of the relationship between accounting events and investment behavior have been conducted at both the individual and market levels. Results from the former type of studies are difficult to generalize because the environment in which such experiments are often conducted differs from the real world in several important respects. (II.2)

5. Empirical studies at the market level have used two different approaches. Valuation models are so dominated by the scale factor that the effect of changes is hard to detect. These models view the problem of valuation of each stock in isolation from other stocks. The second approach uses the capital market equilibrium model which is not only formulated in terms of price changes but also takes a portfolio view of investment decision. The latter approach is used in this study. (II.3)

6. With inflation and steady or increasing physical inventory, the economic value of the firm increases and the reported income decreases when it adopts LIFO. If market's expectations are formed on the basis of the reported income alone, stock price of such firms should also decrease. If the market does not get "fooled" by the effect of accounting changes on the earnings, stock price should increase. The opposite is true for the firms which change their accounting method from LIFO to FIFO. (III.4)

7. Sources of data for this study are the Accounting Trends and Techniques, the annual reports of various firms, the C.R.S.P. Monthly Stock Price Relative File and Moody's Industrial Manual. (III.5)

8. In order to measure the abnormal price changes associated with the accounting changes, sensitivity of the price of each stock to the market factor (also called relative risk) is estimated under the assumption that it is an unchanging parameter. On average, the stock price of firms which changed over to LIFO increased during the 12 months preceding the accounting change. Post-change price movements were considerably smaller. The average stock price of the firms which changed from LIFO to FIFO declined after the accounting change. The latter sample, however, was small and its results are not statistically significant.

9. The price increase observed for firms which adopted LIFO might be reflective of the good health of the firms and their business prospects which, in turn, might have motivated the management of these firms to bring about the accounting change. Since decisions to change the accounting procedures are more likely to be taken near the end of the fiscal year, all the price increase during the twelve months preceding the close of fiscal year could not be explained as an effect of the accounting change. The lack of availability of data did not permit further identification between these two interpretations. (IV.4)

10. It is, however, clear that the market price of the stock of these firms moved with their economic value and not with their reported income when the effect of an accounting change of the value and the income was in opposite directions. (IV.4)

11. The adoption and abandonment of the LIFO method may be associated with changes in relative risk (sensitivity of the stock price to the market-wide price movements) of the firm in the presence unanticipated price-level changes. The existence of such association depends on the validity of the Sharpe-Lintner model in the presence of

unanticipated inflation. The direction of the association depends on the existence of wage-lag and debtor-creditor status of the firms in the market. (V.2)

12. Since adoption of the LIFO method is found to be associated with an increase in the market price of the owners' equity, it results in a lower debt equity ratio. Since the relative risk of a firm is a linear function of debt equity ratio, the adoption and abandonment of the LIFO method should also be associated with a reduction and increase in relative risk respectively. (V.2)

13. Ordinary least square estimates indicate that relative risk of the firms which changed their accounting method to LIFO increased after the accounting change. Relative risk of the firms which changed to FIFO decreased after the accounting change. (V.3)

14. The measurement of abnormal price changes can be affected by the presence of risk changes. If changes are not properly accounted for, the resulting measurement of association between accounting and price changes can be misleading. (V.4)

15. It is possible to model the behavior of relative risk in the framework of random coefficients model with or without the presence of serial correlation. Hypotheses about the stability of relative risk can be tested in presence of an unknown degree of serial correlation. Monte carlo experiments are conducted to prepare the tables for such hypothesis testing. (VI.1 to 6)

16. Tests on stock price data of the firms which changed their accounting method for inventory valuation to or from LIFO rejected the null hypothesis that their relative risk during the years surrounding

the accounting change was constant. (VI.6)

17. A rough estimation of variance and serial correlation of relative risk of these stocks indicated that the value of these parameters lies in the ranges 0.06 to 0.25 and 0.95 to 0.99 respectively. (VI.6)

18. The presence of a high degree of serial correlation in the risk coefficient suggests that its behavior can be modeled as a random walk. The adaptive regression model proposed by Cooley and Prescott can be used to estimate the relative risk of a firm at various points in time. Parameter $\sqrt{\lambda}$, which partitions the total price return variance between the step variance of relative risk and the disturbance term of the market model can also be estimated with the help of this procedure. (VII.2)

19. Estimation of the time path of the relative risk of the firms which changed to LIFO indicated that their risk increased by about 5 % during the 24 month period surrounding the date of accounting change. A large proportion of this increase took place during the 12 months preceding the accounting change. Relative risk of the firms which changed to FIFO decreased by about 5 % during the 24 month period around the accounting change. (VII.3)

20. After adjustment for changes in relative risk, the abnormal increase in the price of stocks which changed to LIFO was 4.7 % during the 12 months immediately preceding the accounting change to LIFO. (VII.3)

2. CONCLUSION

In this section we state the conclusions from and implications of the results obtained in this thesis. We shall first look at the substantive issues of concern to various economic agents and then turn our attention to the methodological aspects relating to the research design itself.

SUSTANTIVE ISSUES

It has been mentioned in Chapter I that the relationship between changes in accounting procedures and behavior of investors is of interest to the corporate managers, investors, auditors and the policy makers for financial reporting standards. In the following paragraphs, we shall interpret the results of this study for each of these classes of decision makers.

Corporate Decisions

It is well recognized that with inflation and a stable or rising inventory position, the LIFO method of inventory costing leads to deferment of tax payments, and therefore to an increase in the economic value of the firm. Two reasons have been advanced to explain why, given this advantage, most corporations have not adopted this method of accounting: (a) Since LIFO accounting precludes the realization of inventory holding gains, the reported earnings under LIFO are generally lower than under FIFO or Moving Average Cost methods. Corporate managers are believed to be wary of reporting lower income because of its possible effect on the market price of their stock and

consequently on their own job security and remuneration. This explanation of corporate behavior implies certain divergence between the commonly held corporate goal of maximizing the wealth of the shareholders and the managers' goal of maximizing their own remuneration because it assumes that the market behaves irrationally in viewing the reduction in corporate earnings due to LIFO as an indicator of adverse corporate health. (b) The second explanation of the failure of most corporations to adopt LIFO has been that the ex post rates of inflation may not reflect the expectation of inflation. Corporations would have adopted LIFO if they had expected that the prices would continue to rise.¹ According to this view, in the years following the War, memories of the Depression were still too fresh and no firm wanted to be caught with an inflated inventory if prices declined. Since the tax law provides that the users of LIFO cannot use the Lower of Cost or Market rule, corporations would have to pay taxes on extra income generated by inflated inventories in times of price level decline.

Results of this study lend no support to the view that the market reacts adversely to the reduced earnings caused by the adoption of LIFO. In fact the stock price of corporations which adopted LIFO increased by about 5 % over and above the market during the

¹"Many companies are likely to delay adoption of LIFO awaiting some future time when cost price levels may reach a lower point." McAnly (1952, p. 123); "The adoption of LIFO will continue to be postponed in the event of further price increases, by the majority of industries waiting some future time when costs reach a low point" McAnly (1958, p. 58).

year in which the switch was made. It cannot be claimed that this price rise was caused by the accounting change because it is possible that the firms which made the accounting change might have been those which saw exceptionally good business prospects for themselves and therefore were not concerned about the adverse effect of the accounting change on their earnings. The observed results are consistent with both of the following hypotheses:

- (a) Stock price of the firms which adopt LIFO increases on average because of the accompanying tax advantage.
- (b) Managers of the firms whose business prospects look good are more likely to adopt LIFO than the others. Therefore the adoption of LIFO was accompanied by a rise in the stock price of such firms. Change to LIFO was not the cause but a related effect of the same factors which led to the price rise.

In all likelihood both these hypotheses account for some part of the observed price changes. Kaplan and Roll (1972) in their study of investment credit and depreciation changes found that the stock price of the firms which had not changed to the flow-through method of accounting for investment credit were, on average, doing better than the market. They also argued that the firms are less likely to switch when they are doing well. In any case, there seems little reason why the managers should hesitate to adopt LIFO for the fear of adversely affecting the price of their stock on the market.

This study is not addressed to the second reason given above for

the corporate reluctance to adopt LIFO.

Investor Decisions

As stated in Chapter I, the shareholders, creditors and financial analysts are often apprehensive that accounting changes may be used by the management to manipulate the financial statements and thus misrepresent the performance and position of the firm. Evidence of this study does not support the view that changes in accounting procedures per se can be used to "manipulate" the market price of stocks. If the accounting changes analyzed here were manipulation attempts by the management of the firms, it must be concluded that they failed. Therefore we can infer that the mechanism through which the market price of stock is arrived at, is able to incorporate the information contained in the financial statements into stock prices even if the financial statements include an accounting change which has been properly disclosed.

Changes in accounting for inventory to (from) the LIFO method are generally accompanied by an increase (decrease) in the relative risk of the firms. Since relative risk is the most important characteristic of stocks for portfolio decisions, the possibility of such change should be taken into account in estimating this parameter from the past stock price data. Failure to do so may result in sub-optimal portfolio decisions.

Financial Reporting Standards Policy and Auditing Decisions

Determining financial reporting standards is a much more complex issue than the corporate and investor problems discussed above because the interests of a much larger and diverse set of economic agents must be considered in making such decisions. Investors, the interest group with which this study has been concerned, are only one of these groups. Other interested groups include the customers, suppliers, employees, government bodies and regulatory agencies and the general public. The study of investor behavior in this thesis has been limited to the aggregate level and the wealth distribution effects of accounting policy, if any, have been ignored. A sound recommendation on reporting practices will have to consider these other aspects of the problem. This study has the following implications which are relevant to the policy of financial reporting:

- (a) At the aggregate level at least, the publication of an annual report which includes an announcement of an accounting change to LIFO is not followed by an observable price movement on average. It is worth emphasizing that this statement applies only to the average price changes for a large number of firms and does not imply that the price of each firm moved in step with the market. It is also worth noting that the results observed refer to the market price of completed transactions and no implications can be drawn from this study about the behavior of or effects on the individual investors. Whether some individuals are misled by a financial statement involving an accounting

change may be an important consideration for the policy makers but this aspect is not addressed to by this study.

(b) Accounting change to LIFO is on the average associated with an increase in the market price of stock of the firm and this increase precedes the end of the fiscal year during which the change occurred. This price rise can be due to either of two different interpretations discussed in the previous section;

(i) The price rise is caused by a change to LIFO through the tax advantage accruing to the firm. (ii) The price rise in the market and the accounting change by the management are two manifestations of a single cause--good health of the firm.

If the first of these interpretations is true, a change to LIFO represents inside information until it is disclosed to the market and can be used by the insiders for private benefits. It is possible, and quite likely, that decisions about the accounting change are not announced to the market immediately after they are made. The profit that can be made from the advance inside information about a proposed change to LIFO is relatively small and can be realized only on a large portfolio of such stocks.

METHODOLOGICAL ISSUES

The research methodology originally proposed by Fama, Fisher, Jensen and Roll (1969) has been extensively used to study the relationship between stock price behavior and various economic (including accounting) events. An important assumption of this research design is that the

relative risk of firms is stable over time. This assumption has two major implications:

- (a) In order to measure abnormal price changes, normal price changes must be defined first. The estimates of normal and abnormal price changes under the assumption that the relative risk of firms is stable over time are misspecified when this assumption is not true. In the presence of risk changes, estimates of abnormal price performance can be quite misleading.
- (b) Constant risk assumption ignores the possibility of a systematic relationship between accounting and risk changes.

Comparison between pre-change and post-change estimates of relative risk (Chapter V.3) and direct statistical testing of the stability of relative risk (Chapter VI.7) indicated that the constant risk assumption is not valid for the data. Therefore the research design described in Chapter IV.2 cannot be relied upon to make measurements of abnormal price changes for the purpose of making an inference about relationship between stock price behavior and accounting changes.

The implication of these findings is that a need exists for (a) statistical tests to detect risk changes, (b) estimators of relative risk in an unstable environment, (c) a research design in which the measurement of abnormal price changes includes the possibility of risk changes and (d) a research design to study the association of accounting changes with the relative risk of firms. The following procedures are proposed and used in this thesis to fulfil these needs:

(a) Ordinary least square estimates of relative risk over adjacent segments of time series have been used in some previous studies for testing the stability of relative risk.² Since these estimates are not efficient estimates of risk in the presence of instability, such tests are inadequate. In Chapter VI, estimation procedures from the random coefficients literature have been used to directly test the stability of relative risk without having to actually estimate the risk coefficient. To the best of our knowledge, these procedures have not been applied before in an empirical situation. Additional procedures have been given for cases in which the random coefficients are serially correlated. Monte Carlo studies of hypothesis testing on stability of the slope parameter have been conducted. These results can be used for further statistical testing of the stability of relative risk of stocks.

(b) The adaptive regression model of Cooley and Prescott can be applied to the problem of estimating the time path of the relative risk of individual stocks. Estimates obtained from this model are minimum-variance-linear-unbiased when parameter γ , which specifies the partition of total rate of return variance between the intercept and the slope coefficients of the market model is known. A major advantage of the procedure used here is that parameter γ can be estimated for each stock independently. Previous work by Fisher assumed a common value of this parameter

²Beaver, Kettler and Scholes (1970) and Blume (1971)

for all stocks which implied that all stocks have the same amount of instability.

(c) Abnormal price changes can be measured by using an estimate of relative risk for each month obtained from the adaptive regression procedure mentioned above. Price changes measured in this manner are not contaminated by the effect of risk changes.

(d) Cross sectional average of the estimated relative risk of the firms for each of the 24 months around the date of accounting change can be computed to examine the association between risk changes and accounting changes.

3. LIMITATIONS OF THIS STUDY AND DIRECTIONS FOR FUTURE RESEARCH

An empirical study imposes limitations on its own scope through the requirements of data and research design. This study is no exception. Its limitations are many and it is necessary that the results be viewed in the light of these limitations. In the previous section the implications of this study for various issues have been stated with only a few qualifications. In this section an attempt is made to state explicitly the limitations of the study with respect to the data and research design used with the hope that it will not only help put this study in perspective but also indicate directions for future research.

DATA

Availability of data with reasonable effort in readily usable form has been a major consideration in the selection of the sample and the methodology. Only those firms which changed their accounting method and were surveyed by the American Institute of Certified Public Accountants for their annual publication Accounting Trends and Techniques are included to avoid having to read the annual reports of all the corporations for over twenty years. This sample was reduced further when the firms not included on the C.R.S.P. File had to be dropped.

Monthly price return data were used because they were available on the C.R.S.P. File in readily usable form. The results of the study are conditional on the monthly data because shorter term (daily or monthly) effects of accounting changes, if any, could not be captured in the analysis of monthly data.

Dates of announcement of accounting changes were measured by a

surrogate -- the end of fiscal year in which the change came into effect. Most firms did not announce accounting changes separately from the earnings announcements and even the dates of earnings announcements for the forties and early fifties were not easily available.

Thus the validity of the results of this study is at leastly partly dependent on the extent to which the sample and the data used in this study represent the universe of interest to the reader.

RESEARCH DESIGN

The research design described in Chapter IV.2 and modified in Chapter VII to measure abnormal price changes is based on the capital market equilibrium model and the validity of the research design is dependent on the validity of this model. Some recent work in the finance literature has raised doubts about this model. But as pointed out in Chapter IV.2, no generally acceptable alternative has been proposed so far. Under the circumstances, it was felt that the use of the capital asset pricing model is the best course for the measurement of abnormal price changes,

One of the assumptions of the research design used here is that the stock market reacts quickly and unbiasedly to new information and is efficient in this sense. This assumption has been tested for a variety of information sets and has been found to hold in most cases, though certain studies do indicate that for certain kinds of information, it may not hold. In the case of accounting information both the market efficiency and the market response to such information, still remain subjects of investigation. As more and more empirical research is

conducted with different kinds of accounting information, probably this assumption can be made with greater confidence than can be done now.

Previous research in this area has used abnormal price change, price variability and trading volumes as measures of association between accounting events and aggregate stock price behavior. The research design of this study has been extended to include the changes in relative risk. Price variability and trading volume measures have not been used in this study since mere announcement of earnings is known to bring an increase in these statistics and it is not clear what the effect of an accounting change on these statistics will be.

APPROACH

The approach of this study to measure the association between accounting changes and investment decision is limited to the aggregate market level. Such an approach reveals little about the behavior of the individual investors. Studies of individual investment behavior have been discussed briefly in Chapter II. Very little theory is available to relate the two approaches. Probably all that can be said is that what is true for the individual investors may not be true for the market and vice versa. This is merely to state a basic problem in this area.

INFERENCE

Statistical association between accounting events and stock price does not imply a cause and effect relationship between the two. This point has been emphasized in this study because such a relationship has often been inferred even though alternative explanations are available. Frequently, it is not feasible to conduct true experiments

in the social sciences and the only alternative is to design pseudo-experiments in which as many as possible of the alternative explanations for the observed phenomenon can be ruled out. The number of alternative hypotheses is often too large for any single pseudo-experiment to control. The process of verifying a hypothesis in such situations involves repeated testing against a variety of alternative hypotheses; the longer it survives unrejected, the greater the degree of faith in its validity.

The process of studying the relationship between accounting events and investment behavior should be looked at from this standpoint. Studies have to be conducted in a variety of situations, on data from various sources and periods of time and each such study adds to the understanding of such relationship. As pointed out in an earlier section of this chapter, the design of this study does not permit distinction between two hypotheses about the observed price increase of the stocks of the firms which adopted LIFO. There could of course be other hypotheses to explain the observed price changes. We hope that future research will be able to resolve this issue.

POLICY

This study deals with only a modest part of the problem of development of optimal standards of financial reporting. In the absence of better methods, today these standards are determined through a process of bargaining between various interested parties. It is not clear whether optimal financial reporting practices can ever be

determined in the way scientists and engineers determine the optimal route for a moon voyage; or whether optimality of reporting practices can ever be defined in a meaningful and widely accepted way. The policy makers in this area will have to take into account not only the conflicting interests of a variety of economic agents but also the functions of and inter-relationships between the various channels of communication and producers of information in the society. Financial reporting is only one of these channels and it seems unlikely that its role can be properly evaluated without a better understanding of the other parts of the information system.

Appendix I.1

Sample Firms

Group A

Name of Firm	Date of Change
A.V.C. Corporation	December 31, 1947
Allegheny Ludlum Steel Corp.	December 31, 1950
Allegheny Ludlum Steel Corp.	December 31, 1955
Allegheny Ludlum Steel Corp.	December 31, 1956
Allis Chalmers Manufacturing Co.	December 31, 1953
Alpha Portland Cement	December 31, 1951
Dixie Cup Co.	December 31, 1951
Marathon Corp.	October 31, 1952
American Can Co.	December 31, 1951
Climax Molybdenum Co.	December 31, 1946
American Metal Products Co.	December 31, 1950
Ameriacan Standard Corp.	December 31, 1952
Armco Steel Corp.	December 31, 1952
Armco Steel Corp.	December 31, 1959
Armour & Co.	November 1, 1947
Armour & Co.	November 1, 1951
Arnold Constable Corp.	January 31, 1948
Associated Dry Goods Corp.	January 31, 1948
Barker Bros. Corp.	December 31, 1950
Bethlehem Steel Corp.	December 31, 1947
Borden, Inc.	December 31, 1947
Borden, Inc.	December 31, 1950
Briggs Manufacturing Co.	December 31, 1955
Brown & Sharpe Mfg. Co.	December 31, 1951
G.R. Kinney & Co.	December 31, 1950
Budd Co.	December 31, 1956
Pacific Mills	December 31, 1950
California Packing Corp.	February 28, 1957
Calumat & Hecla Inc.	December 31, 1947
J. I. Case Co.	October 31, 1951
Caterpillar Tractor Co.	December 31, 1947
Consolidated Coppermines Corp.	December 31, 1947
Champion Paper & Fibre Inc.	March 31, 1951
Chrysler Corp.	December 31, 1957
Cities Service Co.	December 31, 1947
Collins And Aikman Co.	February 28, 1951
C. F. And I. Steel Corp.	December 31, 1959
Continental Can Co.	December 31, 1947
Continental Steel Corp.	December 31, 1950
Copper Range Co.	December 31, 1947
Cosden Petroleum Co.	April 30, 1948
Crown Cork & Seal Co. Inc.	December 31, 1951
Crown Cork & Seal Co. Inc.	December 31, 1957
Crucible Steel Corp.	December 31, 1951
Crucible Steel Corp.	December 31, 1952
Cyclops Corp.	December 31, 1950

Appendix I.1 (-contd.)

Deere & Co.	October 31, 1951
Derby Oil Co.	December 31, 1947
Diamond International Corp.	December 31, 1951
Eastern Stainless Steel Corp.	December 31, 1956
Eastman Kodak	December 31, 1951
Electric Autolite	December 31, 1950
Firestone Tire & Rubber Co.	October 31, 1950
First National Stores Inc.	March 31, 1952
General Electric	December 31, 1951
General Electric	December 31, 1955
Gimbel Brothers	January 31, 1948
B. F. Goodrich	December 31, 1950
B. F. Goodrich	December 31, 1953
Goodyear Tire & Rubber	December 31, 1950
W. T. Grant Co.	January 31, 1949
Hercules Motors Corp.	December 31, 1947
Hercules Inc.	December 31, 1956
Hershey Foods	December 31, 1955
Cletrac Corp.	October 31, 1951
Hunt Foods & Industries Inc.	June 30, 1951
Indian Head Inc.	November 30, 1962
Inland Steel Co.	December 31, 1950
Interchemical Corp.	December 31, 1950
Interchemical Corp.	December 31, 1951
International Silver Inc.	December 31, 1956
International Silver Inc.	December 31, 1959
International Silver Inc.	December 31, 1962
Johns Manville Corp.	December 31, 1948
Jone & Laughlin Steel Corp.	December 31, 1947
Joy Manufacturing Co.	September 30, 1951
Kroger Co.	December 31, 1950
Lambert Co.	December 31, 1950
Lehigh Portland Cement Co.	December 31, 1951
Lukens Steel Co.	October 28, 1950
R. H. Macy Inc.	January 31, 1949
May Department Stores	January 31, 1948
McCall Corp.	December 31, 1959
Mead Corp.	December 31, 1953
Mead Corp.	December 31, 1959
Medusa Portland Cement Co.	December 31, 1956
Melville Shoe Corp.	December 31, 1952
Continental Oil Co.	December 31, 1947
National Biscuit Co.	December 31, 1950
National Cash Register Co.	December 31, 1951
Bridgeport Brass Co.	December 31, 1950
National Gypsum Co.	December 31, 1951
National Lead Co.	December 31, 1950
Nautec Corp.	June 30, 1958
Pan American Petroleum & Transport Co.	December 31, 1946
Penn Dixie Cement Cotp.	December 31, 1951
Phelps Dodge	December 31, 1951

Appendix I.1 (contd.)

PPG Industries Inc.	December 31, 1947
Pillman Inc.	December 31, 1951
Reliance Electric Engineering	October 31, 1951
Reliance Electric Engineering	October 31, 1957
Republic Steel Corp.	December 31, 1947
Reynolds Metals	December 31, 1952
Reynolds Tobacco	December 31, 1957
Schlumberger Ltd.	March 31, 1956
Scott Paper Co.	December 31, 1950
Screw & Bolt Corp. of America	December 31, 1947
Sharon Steel Corp.	December 31, 1950
Sharon Steel Corp.	December 31, 1963
Signode Corp.	December 31, 1953
Mobil Oil Corp.	December 31, 1957
Sperry-Rand Corp.	March 31, 1951
Square D. Co.	December 31, 1957
A. E. Staley Mfg. Co.	December 31, 1950
Standard Brands	December 31, 1950
Beechnut Life Savers Inc.	December 31, 1951
Stockley Van Camp Inc.	May 31, 1951
Swift & Co.	October 31, 1947
Textron Inc.	December 31, 1959
Tidewater Oil Co.	December 31, 1947
Time Inc.	December 31, 1950
Union Camp Corp.	December 31, 1950
Union Camp Corp.	December 31, 1951
U. S. Steel	December 31, 1947
Union Chemicals & Materials Corp.	December 31, 1950
Westinghouse Electric Corp.	December 31, 1951
Wheeling Steel	December 31, 1955
Wheeling Steel	December 31, 1956
Youngstown Sheet & Tube Co.	December 31, 1950

Group B

Associated Dry Goods Corp.	January 31, 1959
Barker Brothers Corp.	December 31, 1951
Basic Inc.	July 31, 1960
Belding Heminway Co.	December 31, 1959
Briggs Manufacturing Co.	December 31, 1962
Pacific Mills	December 31, 1955
Calumet & Hecla Inc.	December 31, 1959
Emhart Corp.	December 31, 1965
B. F. Goodrich	December 31, 1963

Appendix I.1 (contd.)

Goodyear Tire & Rubber	December 31, 1964
Graniteville Co.	December 31, 1965
W. T. Grant	January 31, 1957
Wesson Oil & Snowdrift Co.	August 31, 1953
Hupp Corp.	September 30, 1963
Indian Head Inc.	November 30, 1955
Johnson & Johnson	December 31, 1963
Kellogg Co.	December 31, 1955
Kendall Co.	April 30, 1953
Libby McNeil & Libby	June 30, 1966
Maytag Co.	December 31, 1960
Melville Shoe Corp.	December 31, 1957
Melville Shoe Corp.	December 31, 1958
Sherwin Williams Co.	August 31, 1951
Trans United Industries Inc.	December 31, 1958
Trans United Industries Inc.	December 31, 1959
Wheeling Steel	December 31, 1966

APPENDIX I.2

Industry Profile of the Sample

SIC Code	Industry	Group A	Group B	Total
100	Mining	3		3
200	Food Products	13	3	16
211	Tobacco	1		1
220	Textiles	3	7	10
260	Paper	9		9
270	Printing and Publishing	3		3
280	Chemicals	5	1	6
291	Petroleum	7		7
301	Rubber and Plastics	4	2	6
314	Leather and Shoe	1		1
320	Clay, Glass and Roofing Materials	7	1	8
331	Steel and Iron	23	1	24
333	Non-Ferrous Metals	5	1	6
340	Fabricated Metal Products	8	2	10
350	Machinery except Electrical	9	1	10
360	Electrical Equipment	8	1	9
370	Transportation Equipment	4		4
380	Instruments	3	1	4
390	Jewelery	3		3
500	Retail Stores	10	5	15
	TOTAL	129	26	155

APPENDIX I.3

Multiple Counts Profile of the Sample

	No. of firms	No. of counts in	
		Group A	Group B
Single change in Group A	81	81	9
Single change in Group B	9		9
Two changes (both in Group A)	10	20	
Two changes (both in Group B)	1		2
Two changes (one in each group)	7	7	7
Three changes (all in Group A)	2	6	
Three changes (2 in Group A, 1 in Group B)	2	4	2
Three changes (1 in Group A, 2 in Group B)	1	1	2
TOTAL	113	119+	22

* Some firms changed their accounting method more than once during the period 1946-66. This table gives details of such occurrences.

APPENDIX I.4

Distribution of Dates of Accounting Change

Group	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
A	Dec. 48	Jan. 49	Dec. 50	Dec. 50	Oct. 51	Dec. 51	Dec. 52	Dec. 55	Dec. 57	Dec. 63
B	Dec. 52	Dec. 54	Jan. 57	Dec. 58	Dec. 59	July 60	Dec. 62	Dec. 63	Dec. 65	Dec. 66
Total	Dec. 48	Oct. 50	Dec. 50	May 51	Dec. 51	Dec. 52	Dec. 55	Dec. 57	Dec. 59	Dec. 66

* Dates before which the given percent of firms in the sample made the accounting change.

Appendix II

FIRMS IN CONTROL GROUP C

American La France Foamite Corp.
Amp Incorporated
Abitibi Power and Paper
Addressograph-Multigraph
Affiliated Gas Equipment
Pittsburgh Metallurgical
Alabama Gas Corp.
Allegheny Ludlum Steel Corporation
Allied Albany Paper Corp.
Allied Products Corp.
Allis Chalmers Manufacturing Co.
Aluminum Co. of America
Amerada Petroleum Corp.
American Bakeries Co.
American Broadcasting Co.
American Can Co.
American Colortype Co.
American Crystal Sugar Co.
Truax Traer Coal
American Enka Corp.
American & Foreign Power
American Home Products
Adams Express
American Metal Climax, Inc.
Kelvinator Corp.
American Optimal Co.
Mullins Manufacturing Co.
American Republics Corp.
American Ship & Commerce Corp.
American & South African Investment Ltd.
American Telephone & Telegraph
American Tobacco Co. (Com.)
Ametek, Inc.
Amsted Industries, Inc.
Chile Copper Company
Anderson Clayton
Apco Oil Corp.
Arlan's Dept. Stores Inc.
Armco Steel Corp.
Armstrong Cork Co.
Art Metal Construction Co.
Ashland Oil & Refining Co.
Stix, Baer and Fuller Co.
Associated Investment
Atlantic Coast Line R. R.
Atlas Chemical Industries, Inc.
Atlas Corp.
Austin Nicholas
Canteen Corporation
Crosley Corporation
Avon Products Inc.
Baker Oil Tools, Inc.
Baltimore & Ohio RR
Barber Oil Corp.
Bates Manufacturing Co.
Bayuk Cigard
Beatrice Foods Co.
Beech Aircraft
Bell & Howell Co.
Bendix Corp.
Berman Leasing Co.
Best Foods Inc.
Birmingham Electric Co.
Bliss & Laughlin Inc.
Twin Industries Corp.
Bond Stores
Smith Douglass
Borg Warner Corp.
Bower Roller Bearing Co.
Briggs & Stratton
Brooklyn and Queens Transit Co.
KVP Sutherland Paper Co.
Brown Shoe Co., Inc.
Buckingham Corp.
Haveg Industries
Bullard Co.
Pacific Mills
Burndy Corp.
Butte and Superior Mining Co.
C.I.T. Financial
California Financial Corp.
Calumet & Hecla Inc.
Canadian Breweries Ltd.
Carborundum Co.
Carolina Telephone and Telegraph Co.
Carriers & General Corp.
Caterpillar Tractor Co.
Celanese Corp.
Central Foundry
Central Ill. Public Service Co.
Central Southwest Corp.
Consolidated Coppermines Corp.
Bestwall Gypsum Co.
Champion Papers, Inc.
Checker Motors Corp.
Chesapeake Corp. Va.
Chicago & Eastern Illinois R.R.
Chicago, Milwaukee, St. Paul
Chicago Rock Island & Pa.
Chicago Yellow Cab Co.

APPENDIX II (cont'd)

Chrysler Corp.
Citadel Industries, Inc.
Cities Service Co.
City Stores Co.
Cleveland Electric Illuminating Co.
Cluett, Peapody & Co., Inc.
Coca Cola
C. F. and I. Steel Corp.
Colt Industries Inc.
Columbia Gas System Inc.
Commercial Credit Co.
Conde Nast Publications
Conley Tin Foil Corp.
Consolidated Edison Co. of New York
Consolidated Laundries Corp.
Mengel Co.
Hazel Atlas Glass Co.
Fidelity-Phenix Fire Ins.
Continental Steel Corp.
Cooper Industries

APPENDIX III

50 VALUES OF x USED IN MONTE CARLO EXPERIMENTS

-0.106305	-0.162354	0.098428
-0.130440	0.000392	0.084252
0.160811	0.048883	-0.054344
-0.000786	-0.004112	0.030479
-0.059446	0.104473	0.139919
-0.026044	-0.063077	0.031746
0.106740	-0.056778	0.047512
-0.006634	0.210977	0.006598
-0.102642	-0.019581	0.078716
0.011565	-0.121122	0.117645
-0.143059	-0.100217	-0.090215
-0.093729	-0.034678	-0.029899
0.080666	-0.105035	0.099072
-0.034332	-0.067678	-0.042465
0.012474	0.018955	-0.015587
0.027886	0.042162	0.004749
-0.123268	-0.165977	

SAMPLE STATISTICS:

Mean:	-0.007893
Standard Deviation:	0.087824
First Order Serial Correlation:	0.021268

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