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The association between arbitrage pricing theory risk measures and traditional accounting variables

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THE ASSOCIATION BETWEEN ARBITRAGE PRICING THEORY RISK MEASURES AND TRADITIONAL ACCOUNTING VARIABLES

by

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DISSERTATION

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ABSTRACT

THE ASSOCIATION BETWEEN ARBITRAGE PRICING THEORY RISK MEASURES AND TRADITIONAL ACCOUNTING VARIABLES

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According to the Arbitrage Pricing Theory (APT), actual security returns depend on a variety of pervasive economic and financial risk factors; as well as firm or industry specific influences. The sensitivity of an asset's returns to unanticipated changes in the pervasive risk factors reflects the security's measure of systematic risk. In equilibrium, the expected security return is a linear function of the sensitivities of actual security returns to unanticipated changes in the pervasive risk factors.

The APT does not specify the number or the nature of the pervasive risk factors. Factor analysis of stock returns can be used to determine sensitivities of individual securities to pervasive risk factors without having to identify these risk factors.

In this dissertation we empirically tested the following question: 'Can we use traditional accounting risk measures from the current period to explain cross-sectional variations of the APT risk measures (sensitivities) in the next period?'

The empirical analysis was carried out using a sample of manufacturing companies from the Compustat data tapes. The study covered two time periods: 1983-1986 and 1988-1991.

The dependent variables were the APT risk measures, derived from a principal factor analysis of daily stock returns. The set of independent variables was an extensive list of traditional accounting risk measures associated with a firm's operating and financial activities. The accounting risk measures used in this study represented the firm's liquidity, debt management, profitability and efficiency, business risk, and market value ratios, as well as the size of the company.

Relying on predictive correlation analysis and multiple regression analysis, an association was established between a firm's basic operating and financial characteristics, and the variations of the APT risk measures across a sample of individual companies as well as portfolios of manufacturing companies.

Several variables measuring various characteristics of firms were found to be significant in explaining each one of the APT risk measures. Traditional accounting variables, can be used to explain the APT risk measures across different sample specifications, as well as across different time periods. In this respect variables showing the greatest promise are measures of size, business risk, financial risk, and market power.

INTRODUCTION

The objective of this dissertation is to examine the association between the Arbitrage Pricing Theory (APT) risk measures and traditional accounting risk measures.

Long before the development of modern portfolio theories, risk analysis concentrated on business and financial risk. The risk specifications were measured with the aid of financial accounting variables and/or financial ratios. With the advent of portfolio theories, risk was partitioned into systematic and non-systematic components. Portfolio theories conclude that in a well-diversified portfolio, only the systematic component of risk matters. According to the Capital Asset Pricing Model (CAPM), the systematic risk of a portfolio - also known as market risk - can be measured by the covariation of the portfolio's asset return with the return of the market portfolio of all risky assets. There is an extensive literature on the association and prediction of the CAPM specification of market risk, known as 'Beta,' with traditional accounting and economic variables.

For several years the CAPM was the undisputed favorite theoretical model for the academic community and investment tool for professional investors. In more recent years, researchers have questioned the theoretical and empirical validity of this model. The APT, introduced by professor Steven Ross in 1976, has been offered as the most prominent alternative to replace the CAPM. According to the APT, actual security returns depend on a variety of pervasive economic and financial risk factors;

as well as firm or industry specific influences. The sensitivity of an asset's returns to unanticipated changes in the pervasive risk factors reflects the security's measure of systematic risk. In equilibrium, the expected security return is a linear function of the sensitivities of actual security returns to unanticipated changes in the pervasive risk factors.

The APT does not specify the number or the nature of the pervasive risk factors. Factor analysis of stock returns can be used to determine sensitivities of individual securities to pervasive risk factors without having to identify these risk factors.

This study, therefore, proposes to find company specific characteristics that can explain the differences in sensitivities relative to the APT risk factors across firms. More specifically the objective of this study is to establish whether or not the traditional accounting risk measures, such as measures of liquidity, profitability, leverage and turnover, from the current period can be used to explain the cross-section variation of the APT risk measures.

Using a sample of 373 (292) firms over the 1983-1986 (1987-1991) period, principal factor analysis results show that five factors are adequate in representing the return data. Stepwise regression of the factor sensitivities on 27 risk accounting variables indicates that traditional accounting risk measures, reflecting almost all aspects of a firm's operations, can be used to explain the APT risk measures across different sample specifications, as well as across different time periods.

The dissertation is organized as follows. In Chapter I, review is made of the literature on the association and prediction of the CAPM specified market risk with accounting and other variables. An overview of the theoretical model, assumptions, implications, criticism and empirical testing of the APT is furnished in Chapter II. In Chapter III, the outline of the theoretical model and a detailed description of the data set are presented. In Chapter IV, empirical results from correlation and regression analyses of a sample of manufacturing companies for the period 1983-1986 are presented. In chapter V, the empirical tests are run on another sample of manufacturing firms for a more recent period, i.e., 1988-1991. The final chapter summarizes the study and will offer some concluding remarks.

CHAPTER I

AN OVERVIEW OF THE LITERATURE ON THE ASSOCIATION OF CAPITAL ASSET PRICING MODEL SPECIFIED MARKET RISK WITH ACCOUNTING AND OTHER VARIABLES

The objective of this chapter is to review the literature on the association and prediction of Capital Asset Pricing Model (CAPM) specified market risk with accounting and other variables.

The ground for research in this area was laid with the work of Beaver, Ketller and Scholes (1970) on the association between market-determined and accounting-determined risk measures. Several studies followed this pioneering work, the last published study in the area having appeared in 1989[1]. Although the central issue remained the same, these studies differed in one or more of the following aspects: specification of the hypothesis tested (contemporaneous association versus prediction), specification of the explanatory variables (accounting and other variables), choice of statistical methodology, and/or sample specification.

The varying characteristics mentioned above are used to form a framework within which the previous literature is examined. More specifically, based on the description of the set of explanatory variables used in empirical analysis we classify the literature in two major groups: first, studies that used accounting and other variables; and second, studies that focused on specific accounting risk measures.

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[1]Ismail and Kim (1989).

The outline of this review will be as follows. In part one, we examine the significance of these studies. Alternatively, this can be seen as reasons justifying why this issue having attracted so much attention in the past. A presentation of the theoretical model used is furnished in part two. In part three, we proceed with the review of explanatory variables used in most empirical analysis. As was mentioned earlier, we distinguish the following two classes: first, studies using a wide range of explanatory variables; and second, studies confined to the examination of a specific accounting variable. Different technical aspects of previous studies, such as sample specification and period covered, are presented in part four. Finally, the results achieved are discussed in part five.

1. Significance of These Studies

Studies on the association and prediction of market risk with accounting and other variables have reported several theoretical and practical benefits.[2] At the theoretical level, these studies can be seen as an attempt to integrate portfolio analysis (based on utility maximization) with corporate financial theory (based on share price maximization). Breen and Lerner (1973) use the following argument: If the market perceives that changes in a firm's financial and operational decisions will be influential on corporate returns and risk, the market risk (β_i) will fluctuate in response to these actions, "β_i therefore provides a link between corporate behavior and the

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[2]The distinction between theoretical and practical benefits is not always clear.

market for corporate shares."[3] At the practical level, by far the most often cited benefit is that both corporate managers and investors will be able to understand how corporate decisions affect the systematic component of risk.

Several studies refer to benefits resulting from risk prediction.[4] This is important because investors equipped with this knowledge will be able to maintain or revise the risk exposure of their portfolios so that it complies with their risk preferences. Logue and Merville (1972) even argued that investors should ask for the publication of information on future financial and operational policy in their annual reports. Inclusion of "forecasted" financial data would help investors in detecting potential changes in the financial and operational policies which might affect return, risk, and, in turn, the price per share of the firm.

Thompson (1976) claimed that these studies would help accountants to develop new tools (measures) to aid in the quest toward risk prediction. Hill and Stone (1980) argued that it would help accountants to assess the usefulness of already existing accounting measures. Logue and Merville (1972) claimed that managers would consider the share price impact of their financial and operational decisions. This would introduce the influence of investor's expectations into the firm's planning process.

Several other important benefits are mentioned in the study of Hill and Stone (1980). The authors refer to the use of beta-based capital decisions "by imputing a

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[3]Breen and Lerner (1973), p. 339

[4] Beaver et al. (1970), Elgers (1980), and Hill and Stone (1980).

project's beta from its financial projection".[5] This is crucial when it comes to risk prediction to be used either in capital budgeting or for the valuation of non-public companies. Foster (1986) referred to the advantage of estimating the betas of firms for which we do not have enough historical stock return data.[6] Hill and Stone point to another area that can benefit from these studies; namely, that of "rate regulation based on accounting measures of fair return."[7]

According to Logue and Merville (1972), "firms may target *beta* and take appropriate steps to achieve it through some combination of financial, marketing, and production policies during the capital budgeting process." The study of Blume (1975) could be seen as lending support to this argument. Blume presents the mean reversion tendency of betas, i.e., the tendency of estimated betas towards a mean of one. This is attributed to statistical and economic factors. Economic factors may indicate a firm's preference to undertake new projects with a beta closer to the mean of one.

The potential benefits from these works came under attack in the studies of Eskew (1979) and Elgers (1980). The latter argued that beta prediction models using accounting variables do not enable risk predictions that are superior to market based forecasts. Eskew (1979) and Elgers (1980) claimed that the superior results of models based on accounting variables should be attributed to the instability over time

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[5]Hill and Stone (1980), p. 595

[6]" The multivariate model ... could be used to estimate the betas of the firms that are newly listed." Foster (1986), p. 350.

[7]Hill and Stone (1980), p. 595.

of market risk and the "shrinking effect" of the ordinary least squares regression model.

However, even if one accepts this criticism, there is still an undisputed benefit to be had from the methods presented in this literature. The use of accounting variables enables the estimation of both the systematic risk associated with, and, the market value of non-public or newly listed companies.

2. The Theoretical Model

According to the Capital Assets Pricing Model,[8] in equilibrium there is a direct linear association between expected return of a security and market risk (β_i), i.e.,[9]

$$E(R_{it}) = R_f + [E(R_{mt}) - R_f]\ \beta_i \tag{1.1}$$

where

$E(R_{it})$ is the equilibrium expected return for asset i during period t,

R_f is the rate of return on a risk free asset,

$E(R_{mt})$ is the expected return from the market portfolio during period t,

β_i is the measure of the systematic component of risk,

Market risk (β_i) is estimated in practice by applying least squares regression analysis to the time series of individual ex-post stock returns versus the ex-post

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[8]See Sharpe (1964) and Sharpe (1991).

[9]Although there are several studies which summarize the CAPM, Modigliani and Pogue (1974a and 1974b) in a series of two articles in the *Financial Analysts Journal* provide an intuitive presentation of the model.

returns of the market portfolio. This estimated regression model, known as the market model is given by (1.2)[10]

$$R_{it} = a_i + b_i R_{mt} + e_{it} \tag{1.2}$$

where

R_{it} are the ex-post returns for the asset i during period t,

R_{mt} are the ex-post returns from the market portfolio during period t,

e_{it} represents the non-systematic component of stock returns,

b_i is the estimated β_i, and

a_i is the estimated intercept associated with the linear relationship.

The estimated slope coefficient is the measure of market risk or the degree of covariation of the individual security with the market portfolio. The values of b_i reflect a proportional relation with risk in the sense that higher betas will imply a higher exposure to systematic risk. Since the market has by definition a beta of one, this serves as a benchmark facilitating further comparisons. Thus, an estimated market risk (b_i) equal to one implies a riskiness for the security equal to that of the market.

Beta is the result, it is the measure of risk. Portfolio theory does not explain why security A varies more with the market portfolio (has a higher beta) than security B. What are the underlying factors that determine a security's risk level? The answer to this question is important for the investment community.

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[10]Basically equation (1.2) is the empirical estimation of the Market Model. CAPM and the Market Model are compatible under certain restrictive assumptions. See Beaver (1972) and Fama (1968).

According to Capital Market theory, market risk is determined solely in the market based on security prices. Furthermore, market efficiency implies that stock prices do reflect all available information. In other words, preferences of the investment community, economic and political events, and corporate decisions (financial, production and marketing) are impounded in stock prices. Therefore, market risk is ultimately determined by all of these economic factors, political events and corporate decisions to the extent that they are systematic, i.e., have a pervasive influence on market prices.

Beaver et *al.* (1970) claim that relying solely on market prices in order to determine market risk is not enough.

> "Our knowledge of risk determination is incomplete as long as we do not know what exogenous variables (i.e., data) are impounded in assessments of security prices and price changes. Observed prices (and price changes) are the net result of the decision process of the entire investment community."[11]

Attempts to explain and predict a firm's exposure to total risk were existent long before the development of the portfolio theory. Financial-statement-based ratios have been associated with risk since the previous century. Horrigan (1968) refers to the work of Winakor and Smith, "A Test Analysis of the Unsuccessful Industrial Companies," as the first systematic work in pursuit of finding indicators of business failure from the financial statement.[12] Besides prediction of financial distress,

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[11]Beaver et al. (1970), p. 654.

[12]Horrigan (1968), p. 288.

studies were developed relating accounting information with several other aspects of risk.[13]

Traditional accounting risk measures reflect decisions of the entity to change its policy (financial and/or operational). If the market perceives that these changes will alter the company's returns, stock prices will respond accordingly. In addition, changes in the firm's policy could also influence the level of the company's market risk.

Such simplified reasoning ignores an important factor; however. Changes in the corporate decisions affect the market risk only to the extent that this influence is systematic (non-diversifiable). Hence, it is unrealistic to expect a perfect association between market risk and accounting risk measures. We find this argument in Beaver *et al.* (1970), as well as in Bildersee (1975), which state that accounting risk measures are capturing the total risk while market risk reflects only the systematic component of risk. More specifically, Beaver *et al.* write,

> "If the systematic and individualistic components of risk are positively correlated (at the extreme perfectly correlated) then it is reasonable to view the accounting measures as surrogates for systematic risk as well. ... The evidence indicates that positive correlation does exist."[14]

We continue this review with a theoretical model that has been the underlying foundation for the majority of these studies. The model assumes that the true

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[13]Barnes (1987) has provided an excellent review of the basic attributes of financial ratios and uses of ratios in several areas.

[14]Beaver et al. (1970), p. 659.

regression model relating market risk with the accounting and other variables is given by the following equation:

$$\beta_i = f(F_i) + \zeta_i \tag{1.3}$$

where

β_i stands for the true measure of market risk for the i[th] security as defined in equation (1.1),

F_i stands for the relevant accounting and other variables assumed to be determining β_i,

ζ_i is the error term associated with the specification of the model.

For b_i, the ordinary least squares estimate of β_i we assume that:

$$b_i = \beta_i + \tilde{u}_i , \tag{1.4}$$

where $\tilde{u}_i$ is the error term associated with the measurement (estimation) of β_i. We further assume that $Cov(\tilde{u}_i, F_i)=0$, i.e., the measurement errors and the explanatory variables used in the regression model (1.3) are independent. The regression model - used for the empirical analysis of this study - is estimated with b_i as the dependent variable. Adding the measurement error term in both sides of equation (1.3) yields the following model:

$$b_i = f(F_i) + (\zeta + \tilde{u}_i) \tag{1.5}$$

Given these assumptions, the estimated slope parameters will be unbiased and consistent since $E(\tilde{u}_i, F_i)=0$.[15] A model specified in a manner similar to equation (1.5) was used in the majority of studies employing empirical analysis.

Rosenberg and Guy (1976), using a numerical example, derived a model that explains the level of a firm's market risk as being determined by two components: the proportional contribution of economy wide events to market variance, and the response of security returns to these events. They write that:

$$\beta_i = \sum_j \left[\frac{V_j}{\sum_j V_j} \right] \gamma_{ji}, \tag{1.6}$$

where V_j is the contribution of j^{th} economy wide event to market variance, and γ_{ji} is the response coefficient of the security i to these events compared to the market response.

With equation (1.3) we attempt to predict/measure the relative response coefficient (γ_{ji}). The first term of (1.6) is common across all securities. It is the γ_{ji} which is a stochastic function of the firm's financial and operational policies.

In the following section we proceed with the review of the set of explanatory variables used for the empirical implementation of these studies.

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[15]One more assumption implied by the structure of the error term in equation (1.5), is that of the additivity of errors.

3. Explanatory Variables.

Classification of studies based on their choice of explanatory variables leads to the formation of two major groups: studies using a wide range of explanatory variables and studies which are confined to the examination of some specific accounting variable.

3.A. Studies Using a Wide Range of Explanatory Variables

The majority of these studies use accounting risk measures covering the entire spectrum of financial statement analysis. A high degree of generalization forces them to employ the linear association between market risk and explanatory variables. As a result, there is no strong theoretical justification for the variables used in each model. Most of the time, the choice of the explanatory variables is based either on previously conducted correlation analysis or some stepwise regression procedure.

Groundwork for this type of analysis was laid by the study of Beaver *et al.* (1970) in which they introduce a set of accounting risk measures that has been used as a basis by most subsequent studies. In their study, Beaver *et al.* used a set of explanatory variables that attempts to capture "most of the important relationships suggested in the literature"[16] In order to justify their choice of explanatory variables, they used arguments from security valuation theory for dividend payout, the theory of Modigliani and Miller (MM) for use of leverage, empirical findings for size, and portfolio theory variability and covariabiltiy of earnings.

The explanatory variables and their specifications were as follows:

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[16]Beaver *et al.* (1970), p. 660.

1. Average dividend payout. It was defined as the sum of distributed dividends over the time period, divided by the sum of earnings over the same period.

2. Average growth of total assets. It was specified as the natural log of the asset size at the end of the period, divided by the log of the assets at the beginning of the period. This ratio was subsequently divided by the number of years within the time period.

3. Average leverage ratio. For each year in the examined period, the ratio of total senior securities to total assets was calculated. The arithmetic average of these ratios over the specified time period was used in their empirical analysis.

4. Average liquidity. It was defined as the average annual current ratios over the period under examination.

5. Average size of total assets. This was specified as the average of the natural log of total assets over the relevant time period.

6. Variability of earnings. It was defined as the (population) standard deviation of the earnings-price ratio. The ratio was defined as income available for common stockholders to market value of common stocks.

7. Covariability of earnings (accounting beta).[17] This variable was defined as the slope coefficient from the regression of firms' earning-price ratio on the average earnings-price ratio of the NYSE, COMPUSTAT firms.

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[17]The specification of the accounting beta as the covariability of earnings was influenced from portfolio theory. It is known as the accounting beta in order to distinguish it from the market risk beta.

Shortly after the study of Beaver et al., (1972), Logue and Merville presented their study on the association between market risk and accounting variables. They justified the set of explanatory variables used in their empirical analysis with the following argument:

> " β_i ... embodies the collective judgment of investors concerning the degree to which macroeconomic conditions will affect the corporation. In particular financial policies may mitigate or amplify changes in the economic climate. ...After going through myriad interfirm comparisons, the market as a whole determines the relative volatility or security of each firm's securities to a broad based market index reflecting aggregate conditions and expectations."[18]

As a result, β_i depends on all the policies/characteristics by which firms may be compared. In their empirical implementation, Logue and Merville, focused on β_i as a function of financial information because all other corporate characteristics are reflected in the financial policy of the entity. They used the following ratios:[19]

1. Liquidity ratio (current ratio).

2. Leverage ratio. They used two specifications, (i) short term liabilities to total assets, and (ii) long term liabilities plus the par value of preferred stock to total assets.

3. Dividend ratio (payout). It was defined as per share dividend divided by earnings per share.

4. Investment ratio. It was specified as the annual compounded growth rate of total assets.

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[18]Logue and Merville (1972), p.

[19]All of the ratios used were specified as the average value of the relevant variable over the examined time period.

5. Profitability ratios. They experimented with two specifications, the total assets turnover (Sales to Total Assets) and profit margin (Operating Earnings to Sales).

6. Size. It was defined as the natural log of total assets.

Compared to the study of Beaver *et al.*, the authors differentiate their set of explanatory variables in the following ways. First, regarding the leverage ratios, they distinguish between short term and long term liabilities. They argued that investors, in their interfirm comparisons, have a different perception of the importance of these two leverage ratios. Second, they introduced two profitability measures, total assets turnover and profit margin. These ratios represent profitability aspects of financial management and control in interfirm comparisons. They did not include in their empirical analysis the two specifications of earnings, variability and covariability. The authors claim that at empirical level, both of these variables were "devoid of explanatory power." Besides these minor alterations their set of explanatory variables is similar to the one in Beaver *et al.*

Breen and Lerner (1973) rely on the asset valuation models in order to justify the set of explanatory variables that they used in their study.

> "Within the context of direct valuation models, several important studies have emphasized earnings growth and dividends payout as important determinants of price or price earnings ratio. *The basic Gordon valuation model of course stresses growth and dividend payout.* Other variables common to these valuation studies include a marketability factor, some measure of volatility of explanatory variables and a measure of leverage."[20]

[20]Breen and Lerner (1973), p.

They use a set of seven explanatory variables specified as follows:

1. The ratio of debt to equity. It was defined as long term debt to equity.[21]

2. The debt to equity ratio squared.

3. The growth of earnings. It was calculated as "the slope of the least squares trend line through the earnings per share available to common equity holders over a moving five year period."[22]

4. The stability of the growth of earnings. It was measured by the value of the coefficient of determination for the equation used to estimate the growth of earnings.

5. Size of company. It was specified as the number of shares outstanding, multiplied by the market price of the company's stock on the terminal date of the period.

6. Dividend payout ratio.[23] The dividend paid during the firm's fiscal year divided by the reported earnings for the year.

7. Trading volume. It was measured as the number of shares traded during the twelve month period ending when the firm reported its financial data.

A careful examination of the set of explanatory variables used by Breen and Lerner reveals that their contribution lies in the use of the following variables. First,

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[21]They experimented with one more form of leverage ratio. They defined the numerator to include the sum of reported liabilities capitalized leases and preferred stock. The retained only the long term debt to equity ratio since both specifications showed similar results.

[22]Breen and Lerner (1973), p. 342. It is just another version of the accounting beta.

[23]The authors experimented with the ratio of the sum of dividends divided by the sum of earnings; each calculated over a three year period. Both specifications gave similar results.

relying on the empirical work of Modigliani and Miller (1958), they introduced the square of the leverage ratio. Second, they examined the impact on the market beta of a measure of the stability of the growth of earnings. Finally, they added the market based measure of size and trading volume.

Rosenberg and McKibben (1973) used one of the most extensive sets of explanatory variables for their regression analysis. This set contained 32 descriptors that "were selected without any prior fitting to the data on the basis of studies reported in the literature and authors' intuition." They classify their independent variables into three categories: accounting based, market based, and market valuation descriptors.

They initially regressed all 32 descriptors on the market risk measure. After deleting those which were insignificant, they retained the following ten explanatory variables:[24]

1. Standard deviation of a measure of growth of earnings per share.
2. Accounting beta, defined as the covariability of earnings with overall corporate earnings.
3. Latest annual proportional change in per share earnings.
4. Dividend payout ratio.
5. Log of mean of total assets.
6. Standard and Poor quality rating.

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[24]The complete list of 32 descriptors appears on Rosenberg and McKibben (1973), p. 325.

7. Historical beta, derived from a regression of stock return on market return over preceding calendar years in the sample, assuming alpha equals zero.

8. Share turnover as a percentage of shares outstanding.

9. Log of unadjusted share price.

10. Book value of common equity per share price.

The study of Rosenberg and McKibben (1973) and a subsequent study of Thompson (1976) used the largest number of explanatory variables. Rosenberg and McKibben introduced several new factors into the set of explanatory variables that we had seen so far; one of them is the Standard and Poor's quality rating. Compared to Breen and Lerner (1973), who used shares outstanding and shares traded in order to capture trade volume, Rosenberg and McKibben prefer shares' turnover, log of the price of shares, and book value.

Lev and Kunintzky (1974) argued that a firm will attempt to buffer its operations from uncertainties in both markets of inputs and outputs in order to attain its maximum efficiency. As a result, the variables that they used reflect a wide range of operations. They distinguish the following groups:

1. Production decisions; such as, production measured as sales plus the change in inventory, sales, and net earnings.

2. Investment decisions; such as, capital expenditure and the ratio of capital expenditures to end-of-year plant and equipment balance.

3. Financing decisions; such as, working capital, the current ratio, the capital structure (measured by the debt/equity ratio), and dividends (measured by

three different series: annual dividends, the dividend payout ratio, and the dividends per share).

Lev and Kunitzky argue that "... managements' success in decreasing uncertainty associated with the firm's operations by various smoothing and buffering activities should be reflected in the perceived risk of the firm from an investor's point of view. Accordingly we hypothesize that the extent of smoothness of the firm's operations will be negatively associated with its common stock risk." [25]

Melicher (1974)[26] was the first to apply the findings of the study of Pinches, Mingo and Caruthers (1973). He used principal component analysis in order to reduce the size of the explanatory variables and identify a smaller set of latent accounting risk measures. Melicher computed twenty-eight different variables for electric utilities for which all financial data were available. Using principal component analysis he found that the following seven factors (principal components) account for 85% of the variation:

1. Financial leverage,
2. size,
3. earnings trend and stability,
4. operating efficiency,
5. financial policy (investments),

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[25]Lev and Kunitzky (1974), p. 262. The degree of smoothness is measured by the mean absolute percentage deviation of the actual changes in the variable from the trend.

[26]We do not discuss the study of Melicher and Rush (1974) because it is similar to the Melicher (1974).

6. return on investment, and

7. market activity.

Although a comparison between the principal components in Melicher and the explanatory variables in the previous studies is difficult to make, it can be seen that, with the exception of the dividends, all the other major categories are reflected in Melicher's set.

The idea of combining accounting and other variables was first introduced in the study of Logue and Merville where they argued that market risk, "functionally depends on the items by which the firms may be compared." As such, they name the "financial policy, market policy, production policy, and corporate policies and decisions which do not specifically relate to any of the functional areas, but are comparable from corporation to corporation." Later in their analysis, however, the authors focus on financial policy variables because the influence of the other variables is reflected in the financial measures of the firm.

It was the study of Bildersee (1975) that attempted to combine accounting variables and decision variables in an empirical analysis. Based on previous studies, theoretical postulates, and empirical findings, Bildersee uses the following eight accounting variables:[27]

1. As a measure of profitability he used the income available for common over common equity.

2. Liquidity was measured by the current ratio.

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[27]He selects only one ratio from each of the several generally accepted classes of ratios.

3. Efficiency was represented from the ratio of sales to common equity.

4. Coverage of fixed obligations from operations, was given from the ratio of cash flow to debt plus preferred stock.

5. Common equity was used as a measure of firm's size.

6. The growth rate of firm. This variable was represented by the geometric average of the annual growth of the assets of the firm.

7. A measure of variability of earnings. As such the author used the standard deviation of the earnings/price ratio.

8. The accounting beta.

Up to this point Bildersee's contribution was the introduction of the cash flow to debt ratio into the set of explanatory variables. This ratio had an impressive record in bankruptcy prediction studies. However, the real path-breaking aspect of Bildersee's study, as far as the explanatory variables are concerned, came from the set of the decision variables that he introduced into the empirical analysis.

He used the following decision variables:

1. The firm' s decision to change its dividend policy on its preferred stock by beginning or ending an arrearage.

2. The firm's decision to reduce its regular common dividend payment to zero.

3. The firm's ability to cover its interest and preferred dividend obligations during every year of the sample period.

4. The firm's diversification within its industry.

The following study that we review by Thompson (1976) brings together several of the previous works considered. He created covariant forms, variances, means and trends of the explanatory variables to be used in the empirical analysis.

Influenced by portfolio theory, he introduced covariant forms for all of the explanatory variables. Previous studies had used only the earnings in covariant form (accounting beta). Thompson expanded this practice to the rest of the explanatory variables. Other than covariant forms, he specified the set of explanatory variables in variance form. The reasoning behind this specification was that smaller variances for accounting variables would reflect an attempt on the part of the company to reduce environmental risk. Explanatory variables expressed in the form of variance are seen as a measure of smoothness.[28] Finally, following the tradition of most previous work he introduced means and trends.

Thompson gives an elaborate explanation of why he used the above mentioned specifications of explanatory variables, but he did not explain the choice of the specific set of variables. For means and trends, he mentions that previous research associates them with systematic risk.

Out of a total of forty five considered variables, Thompson uses the following thirteen variables.

The first one called the *model*, combines dividends, earnings' multiple, and earnings' stability factors simultaneously in the following formula:

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[28]The idea of examining the impact of smoothing on market risk was first introduced by Lev and Kunitzky (1974). The authors provide a more detailed justification for the use of variances.

$$\frac{Cov(\tilde{d}_i,\tilde{d}_m)+Cov(\tilde{e}_i,\tilde{e}_m)+Cov(\tilde{k}_i,\tilde{k}_m)}{\sigma^2(\tilde{d}_m)+\sigma^2(\tilde{e}_m)+\sigma^2(\tilde{k}_m)}; \quad (1.7)$$

where

$\tilde{d}_i$, $\tilde{d}_m$ are the dividend yields for security *i* and the market portfolio *m* respectively,

$\tilde{e}_i$, $\tilde{e}_m$ are the earnings' relative changes for security *i* and the market portfolio *m* respectively, and

$\tilde{k}_i$, $\tilde{k}_m$ are the multiple of earnings' relative changes (forecasted) for security *i* and the market portfolio *m* respectively.

The second and third dependent variables were two specifications of the dividend stability factor. One specification was the mean of the dividend payout ratio, the other was the dividend's beta.

The fourth and fifth explanatory variables were two specifications of the earnings' multiple stability factor. One specification was the variance of the earnings' multiple, and the second was the beta of the multiple of earnings.

Two specifications of the earnings' stability factor were the sixth and seventh dependent variables. The two specifications were earnings' variance and the beta of earnings.

The eight and ninth explanatory variables reflected the operating income stability factor. They appeared in the empirical analysis as the variance and beta of operating income respectively.

The tenth variable used was the growth factor (asset's growth), while common stock marketability factor (market volume) was the eleventh one. Finally, financial leverage factor (mean debt to total assets) and mean pre-tax income coverage were the last two explanatory variables.

Rosenberg and Guy (1976) used a numerical example to show that the level of beta is determined by two kinds of parameters: the degree of uncertainty attached to various categories of economic events (the proportional contribution of the events to market variance) and the response of the security returns to these events (relative response coefficients).

They used the following set of explanatory variables in their attempt to predict/measure the response coefficient.[29]

1. Variance of cash flow
2. Variance of earnings
3. Growth of earnings per share
4. Market capitalization
5. Current dividend yield
6. Total debt to assets.

Obviously, their contribution in this literature lies in the development of the formula that presents the response coefficient of market risk. The set of explanatory variables used does not differentiate their work from earlier studies.

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[29]The authors did not justify the choice of the variables used. Table 3 on page 67 reports this partial list of the variables that they use.

Eskew (1979) used nine accounting variables in the empirical implementation of his study. The same seven that appeared in Beaver *et al.* (1970), plus earnings' variability and earnings' covariability. However, Eskew's study can be differentiated from Beaver *et al.* (1970) in defining the following variable: "earnings$_t$ divided by net worth$_{t-1}$ instead of earnings$_t$ divided by market value$_{t-1}$."[30]

Elgers' (1980) initial set of explanatory variables contained those variables suggested by Beaver *et al.* (1970) and Eskew (1979). The author used stepwise regression and principal components analyses in order to derive the final set of explanatory variables. Out of a list of twenty-eight specifications of accounting variables based on the stepwise regression procedure he used the following five:[31]

1. Sales beta (adjusted covariant form),
2. dividend payout,
3. cash flow beta,
4. assets squared, and
5. sales variability.

The second approach based on principal components analysis suggested the use of a set of nine principal components for use in the regression analysis. Unfortunately, he did not specify either the weights or the variables used, thus we cannot make any comparisons with the study of Melicher (1974) and Melicher and Rush (1974).

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[30]Eskew (1979), p.

[31]Table B-1 in Elgers (1980), p. 406 provides the list of the twenty eight variables.

The description of studies using a wide range of accounting and other variables to explain and predict the systematic risk of common equities will be closed with a discussion of the work of Hockman (1983). He used the following three variables in his "fundamental model" for predictions of market risk.

1. Average annual financial leverage. It was specified as long term debt plus current liabilities plus preferred stock divided by total senior securities plus market value of equity.

2. Average dividend yield. The annual measure was defined as annual dividend divided by share price at the end of the estimation period.

3. Systematic business risk. It was based on a regression of seasonal change in after tax operating income over book value on the economy wide index for the same variable.

With Table 1.1 we attempt to summarize the sets of explanatory variables that have been suggested and used in the studies reviewed here. In this table the explanatory variables are classified as variables which are based on or represent dividends, size or investment, leverage, liquidity, earnings, profitability or efficiency, or the stock market.

From the dividends category of explanatory variables, dividend payout is the most popular variable. Beaver *et al.* justify the use of this ratio as "a surrogate for management's perception of the uncertainty associated with firm's earnings."[32] They argue that companies will try to maintain a more or less stable level of dividend

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[32]Beaver *et al.*(1970), p. 660.

payments. In order to avoid having to cut back future dividend payments associated with lower earnings, companies that experience high volatility of earnings tend to establish low dividend payments. Thus, an inverse relationship exists between volatility of earnings and dividend payments. All other specifications used - such as dividend beta, dividend yield - could be justified by similar reasoning.

The second major category of variables that has been suggested and used reflects some measure of size. The most popular measure is total assets and its specifications range from simple growth rate and log of total assets to a geometric average. Sales is the second choice used as a measure of size. Again, we rely on Beaver *et al.* for a theoretical justification for the use of size-related variables. They

TABLE 1.1

COMPARATIVE PRESENTATION OF SETS OF EXPLANATORY VARIABLES

	DIVIDENDS	SIZE or INVESTMENTS	LEVERAGE	LIQUIDITY
BEAVER *et al.*	Dividend Payout	1.Growth TA 2. Log TA	Senior Securities to TA	CR
LOGUE-MERVILLE	Dividend Payout	1.Growth TA 2. Log TA	1. CL/TA 2. CL + Pr. Stock to TA	CR
BREEN-LERNER	Dividend Payout		1.(D/E) 2.$(D/E)^2$	
ROSENBERG-McKIBBEN	Dividend Payout	Log TA		
LEV-KUNITZKY	1.Dividend Payout 2.Annual Dividends 3.Dividends per Share	1. Capital Expenditure to Fixed Assets 2.Sales+Inv 3. Capital Expenditure 4. Sales	(D/E)	1. CR 2. Working Capital
MELICHER		1.Size 2.ROI 3.Financial Policy	Leverage	
BILDERSEE		1.Geometric Average TA 2.Common Equity	Cash Flow to (D + Pr. Stock)	CR
THOMPSON	Dividend Payout	Growth TA	1. D/TA 2. Coverage	
ROSENBERG-GUY	Dividend Payout		D/TA	
ESKEW	Dividend Payout	1.Growth TA 2.Log TA	Securities to TA	CR
ELGERS	Dividend Payout	1.Sales b 2.Var Sales 3.TA^2		
HOCKMAN	Dividend Yield		Fixed Obligations to Equity	

TABLE 1.1 (Cont'd)

COMPARATIVE PRESENTATION OF SETS OF EXPLANATORY VARIABLES

	EARNINGS	PROFITS	MARKET
BEAVER *et al.*	1. Var. Earnings 2. Accounting β		
LOGUE-MERVILLE		1.Sales/TA 2.EBIT to Sales	
BREEN-LERNER	1. Accounting β 2.Stability of Earnings Growth		1.# Shares Outstanding 2.# Shares Traded
ROSENBERG-McKIBBEN	1. SD of Earnings Growth 2. Accounting β 3. % Change in EPS		1.Share Turnover as % of shares Outstanding 2.Log Price of Share 3.Book Value
LEV-KUNITZKY	Net Earnings		
MELICHER	Earnings Trend and Stability	Operating Efficiency	
BILDERSEE	1. St. Dev. of E/P 2. Accounting β	1.Income for Common 2. Sales to Equity	
THOMPSON	1. Var of Earnings 2. Accounting β 3. Var of Earnings Multiple 4. β of Earnings Multiple 5. Var of OI 6. β of OI		Market Volume
ROSENBERG-GUY	Using Price 1.Var of Earnings 2.Growth of EPS Using Net Worth 3.Var of Earnings 4.Growth of EPS		Market Capitalization
ESKEW	1. Var of Earnings 2. Accounting β		

argue that historical data reported in Dun and Bradstreet indicate that large firms have a lower probability to default. Besides this, Beaver *et al.* refer to the findings of Horrigan (1966), in which total assets are credited as being the most important variable in predicting bond ratings.

In the category of leverage ratios, there are several different specifications. Debt to equity or debt to total assets are the most often suggested and used ratios. The rationale for each is that a higher degree of financial leverage will increase the variability of earnings for common shareholders.

Another major category of ratios is associated with earnings. The specification of market risk as the covariability of stock returns with market wide returns has inspired the specification of the most popular variable from the earnings set, namely the accounting beta. This is defined as the covariability of earnings with market earnings. Therefore, the end justifies the means could have been the reason why the accounting beta is the most often used variable in the category of earnings. Other specifications for earnings related variables include the variance and standard deviation of earnings.

In the following section we continue with studies that concentrate on the explanatory power of specific accounting risk measures. Specifically, they examine the influence of operating and financial risk.

3.B. Studies Using Specific Accounting Risk Measures

In this section we concentrate on studies that use certain measures from the financial statement in their prediction models. We review studies that examine the explanatory power of financial leverage[33], operating leverage[34], the combined influence of both[35], and most recently the additional explanatory power of cash flow risk measures[36]. With the exception of Ismail and Kim (1984), the empirical work in each one of these studies is based upon a theoretical model proposed by the respective authors.

Hamada (1972) attempts to estimate the effect of a firms' leverage (capital structure) on the systematic risk of common stocks. Hamada used both portfolio theory and the MM theory to derive the result that, given two firms from the same risk class, the firm with the higher debt-to-equity ratio, should have the higher market risk. He makes the distinction between the observed rate of return of a stock (R_{Bt}) and the adjusted rate of return (R_{At}). The latter reflects what would have been the return over the same time period if the firm was without fixed obligations or preferred stock in its capital structure. To each one of these returns corresponds a measure of systematic risk. If the MM theory is correct, the difference between these two risk measures can be attributed to financial leverage.

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[33]Hamada (1972)

[34]Lev (1974)

[35]Hill and Stone (1980), and Mandelker and Rhee (1984).

[36] Ismail and Kim (1984).

In order to test this argument, Hamada estimated the two measures of systematic risk: the observed systematic risk (β_i) and the adjusted measure of risk (β_i^*). The difference between the two measures lies in the fact that the latter corresponds to a firm without debt or preferred stock in its financial structure.

For the empirical analysis he derived the following functional specifications of the observed (R_{Bt}) and adjusted (R_{At}) rates of return.

$$R_{Bt} = \frac{d_t + cg_t}{S_{D_{t-1}}} \tag{1.8}$$

$$R_{At} = \frac{d_t + cg_t + p_t + I_t (1 - \tau)_t}{(V - \tau D)_{t-1}} \tag{1.9}$$

where,

d_t are the common shareholders dividends,

cg_t are the common shareholders capital gains,

$S_{D(t-1)}$ is the observed market value of common stock,

p_t are preferred dividends paid,

I_t represent interest and other fixed charges,

τ is the corporate income tax rate,

V_{t-1} is the observed market value of the firm, and

D_{t-1} is the market value of debt (τD reflects the tax subsidy for debt financing).

Lev (1974) examined the effect of operating leverage on the total and systematic risks of stock returns. Under certain *ceteris paribus* assumptions,[37] Lev derived a positive relationship between operating leverage and both risk specifications. Since operating leverage was defined as the ratio of fixed to variable operating costs, the previous conclusion was restated as follows: there is a negative association between a firm's level of variable cost and its systematic risk.

It was this last version that Lev tested empirically. In other words, variable cost was the explanatory variable used in the regression model,

$$\beta_j = \alpha + b\,\hat{v}_j + \epsilon_j, \qquad (1.10)$$

where $\hat{v}$ is the unit variable cost. Since there were no variable cost data available in a firm's financial statement, Lev used the following time series regression model in order to derive an estimate of variable cost,

$$TC_{jt} = a_j + v_j\,Q_{jt} + u_{jt}, \qquad (1.11)$$

with

TC_{jt} standing for the total operating cost for the firm *j* during year *t*, and

Q_{jt} standing for either the physical output (electric utilities) or volume of sales (steel and oil companies).

The next generation of studies Hill and Stone (1980), and Mandelker and Rhee (1984) used the formulae developed by Hamada (1969 and 1972) and Rubinstein

[37]He makes the following assumptions: two firms from a homogeneous industry, with identical patterns of sales across states of nature, and equality of total stock value of the firms. They differ on the degree of operating leverage.

(1973). These formulae separate market risk into two components. The first one is intrinsic operating risk or business risk, which is measured by what would have been the market risk for a firm without debt or preferred stock. The second component is financial risk and it measured the impact of debt financing (financial structure) on market risk. According to the Hamada-Rubinstein formulae, financial structure amplifies the impact of business risk on market risk in a multiplicative way.

Hill and Stone (1980) derived what they called the 'accounting analogue' of the Hamada-Rubinstein formula. They developed the accounting equity beta (β^R_i) as a function of the intrinsic operating risk and an accounting measure of financial risk.

For their regression analysis they assume the existence of a stable transformation,

$$\beta_i = f\,(\beta^R_i) + \epsilon_i, \tag{1.12}$$

relating the market measure of risk with the accounting based beta. For the empirical analysis, a version of equation (1.12) is differentiated and the following testable model results:

$$\Delta\beta_i = a_0 + a_1 \left[\frac{\Delta f_i}{1 - f_i}\right] \beta^R_i + a_2 \left[\frac{\Delta\beta^o_i}{\beta^o_i}\right] + a_3 \left[\frac{\Delta FL_M}{FL_M}\right] \beta^R_i \tag{1.13}$$

where,

β_i is the market-measure of equity risk,

β^R_i is the accounting-measure of market risk,

β^{Δ}_i is the accounting-measure of systematic operating risk,

f_i = *(Non Common Equity / Total Assets)* is the proportion of non-common equity financing, and

$FL_M = (\Sigma^N_{k=1} \ \beta^0_k (1 - f_k) / N)$ is an accounting measure of financial leverage, i.e., FL_M it is a measure of the magnification of operating results arising frcm the substitution of nonequity financing for common equity.

Their regression model explained changes in market betas as a function of changes in both the firm's financial structure and operating risk.

Mandelker and Rhee (1984) presented a similar empirical analysis. They started from the Hamada-Rubinstein formulae and derived another operational relationship that showed how the two measures of leverage contributed to market risk.

$$\beta_i = (DOL_i) (DFL_i) \beta^0_i, \qquad (1.14)$$

where "Degree of Operating Leverage" (DOL) is measured by the percentage change in earning, before interest and taxes, that is associated with a given percentage change in units produced and sold. "Degree of Financial Leverage" (DFL) is defined as the percentage change in earnings, after interest and taxes, that results from a change in earnings before interest and taxes. Finally, β^0_i is the intrinsic business risk of common stocks.

They investigated the combined effects of the degrees of the two types of leverage on systematic risk using the following equation,

$$\ln \beta = \gamma_0 + \gamma_1 \ln (DOL) + \gamma_2 \ln (DFL) + e. \qquad (1.16)$$

The independent variables in this model are specified in two ways. First, the authors run the following regressions in order to estimate DFL and DOL.

$$ln\ (\ EBIT_{it}\ ) = \ a_j + c_j\ ln\ (\ SALES_{jt}\ ) + e_1 \qquad (1.\ 17)$$

$$ln\ (\ Net\ Income_{\ jt}\ ) = b_j + d_j\ \ ln\ (\ EBIT_{jt}\ \ ) + e_2\ , \qquad (1.\ 18)$$

where

c_j is the DOL, and

d_j is the DFL.

Their second choice was use of instrumental variables highly correlated with the two independent variables which can be observed independently of the DOL and DFL. The authors considered as natural candidates for this job the operating leverage and financial leverage measured in book values. More specifically, they chose the 20-year average of the ratio of net fixed assets to total assets and the ratio of total debt to total assets as appropriate instrumental variables for DOL and DFL respectively.

The most recent study in this area was conducted by Ismail and Kim (1989). They concentrated on cash flow related variables, examining the additional explanatory power that funds and cash flow specified risk measures (accounting betas) posses over that of earnings risk measures in explaining the variability of market risk.

Ismail and Kim used multiple regression analysis with market risk as the dependent variable and independent variables taken from the following set of accounting betas:

1. Earnings beta, where earnings were defined as income available to common equity divided by beginning-of-period market value of common equity.

2. First Version of Funds Flow beta, where funds flow was defined as income available to common plus depreciation divided by beginning-of-period market value of common equity.

3. Second Version of Funds Flow beta, where funds flow was specified as income available to common plus depreciation and deferred taxes divided by beginning-of-period common equity.

4. Cash Flow beta, where cash flow was defined as income available to common plus depreciation, deferred taxes, and the change in non-cash working capital.

In the following section we continue our literature review with a discussion of the sample specifications used in these studies. More specifically, we look at the type of companies included and the periods covered across these studies.

4. Sample Specifications

The nature of these studies requires both financial accounting data and stock returns for their empirical implementation. For the group of studies that attempts to explain variations in market beta using a wide range of accounting variables, the availability of financial data in COMPUSTAT tapes has been the principal binding constraint in sample selection. According to Beaver *et al.* (1970) sample selection based on "availability" will lead to firms which are relatively large, old, and more successful in the economy. Eskew (1979) raises the same concern regarding sample bias as well as the observation that these firms may be on average less risky. Some studies imposed another constraint beyond the availability of data; i.e., considering only those companies with similar fiscal end-of-year (December 31). The criterion was used in order ensure that information set at any given time contained only present and past data.[38]

Another approach to sample specification was that of concentration upon specific industries for empirical analysis. The most popular groups for this analysis have been the manufacturing groups (most of the studies that have been classified as 'based on availability' were confined to the use of the COMPUSTAT Industrial tapes). Other specific industries chosen were public utilities (Melicher, Lev, Bildersee), transportation (Bildersee), steel, and oil production (Lev).

As far as the periods covered in the empirical analyses are concerned, with the exception of Logue and Merville, all other studies base their analyses on the availability of contemporaneous data for both financial variables and stock returns.

Logue and Merville chose the period to be considered in their study (1966-70) after having recognized that "the finance function played an important role for most corporations owing to the liquidity squeeze of 1966; inflation, and the early part of the recent recession." [39]

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[38]Breen and Lerner (1973), p. 342.

[39]Logue and Merville (1972), p. 42.

5. Comparative Results

In this section, we follow the same framework we used when we reviewed the set of explanatory variables used in empirical analyses. Initially, we summarize the results of studies that use a wide range of explanatory variables. Subsequently, we report the results of studies that concentrate on specific accounting risk measures. In both cases, we discuss only the regression analysis results.

5.A. Studies Using a Wide Range of Explanatory Variables

The results that these studies report are generated by either 'predictive' regression models (they use accounting and other variables from period *t-1*, to forecast the beta in the period *t*) or 'contemporaneous' regression models (they use simultaneous data for both dependent and independent variables). The studies of Beaver *et al.* and Elgers are predictive ones. The rest of the studies attempt to explain fluctuations in market risk with accounting and other explanatory variables from the same period. Another variation regarding the way empirical results are reported is the degree of aggregation in the analysis. We have results at individual security levels, results within industries, and across industries and portfolios.

Regarding the predicted signs of the independent variables, the results vary from one study to another. Most of these studies e.g., Beaver *et al.*, Logue and Merville, and Lev and Kunitzky, report that the predicted signs are in accordance with the theoretically anticipated ones. For others, like Rosenberg and McKibben, the signs are mixed. They report that some of the estimated regression signs comply with the theoretically anticipated ones, but others do not.

Overall the core of significant explanatory variables remains the same across most of these studies. Dividend and size related variables show up with a statistically significant sign. The third category of variables that enters several regression models with a significant sign are earnings. We should mention that this variable appears in many different forms across studies (earnings, earnings beta, variability of earnings, etc.). Other variables appearing to have a significant impact on market risk, as reported in several studies, are leverage and profitability related variables.

Rosenberg and McKibben suggest that both accounting information and historical price behavior of betas should be used to predict future betas. Bildersee argues that accounting and decision variables are associated with similar aspects of systematic risk. However, it appears that the explanatory power of the two types of variables are distinct from each other. Therefore, by adding a set of decision variables to accounting data we could potentially increase the explanatory power of our models.

Breen and Lerner report that estimated regression coefficients (in the accounting variables based beta prediction model) vary across groups of companies with different month selected as its fiscal end-of-year. Melicher reports that there is some indication that the relationships may vary by industry and possibly, by time period. The same comment appears in Bildersee, Eskew and Elgers.

Eskew finds a small, but consistent superiority in beta prediction of the accounting based models over their beta data only counterparts. Elgers, on the other hand, finds that accounting risk measures do *not* improve upon market based systematic risk predictions. He claims that the findings of previous studies showing "superior predictive ability for accounting based forecasts" can be " reinterpreted as due to the instability over time of systematic risk, coupled with the fortuitus "shrinking effect" of the ordinary least squares regression model." He warns that attempts to generalize over time the predictive ability of accounting risk variables as well as the relevance of specific accounting ratios to explanations or predictions of systematic risk, should be done with caution.

Accounting risk measures, when used as explanatory variables, may serve as a proxy for some set of omitted economic variables. According to Elgers the initial choice of the set of explanatory variables was arbitrary since the best set of variables cannot be identified deductively. Therefore, inferences from empirical analyses are conditional on the set of independent variables used. He further states that we cannot expected accounting risk measures to reflect the "combination of firm specific and exogenous economic variables which determine systematic risk."

5.B. Studies Using Specific Accounting Risk Measures

Hamada (1972) found that the estimated mean systematic risk (for the 304 firms in his sample) was higher than the systematic risk of the unlevered firm. Specifically, he argues that if the Modigliani-Miller corporate tax leverage propositions are correct, then approximately 21% to 24 % of the observed systematic risk of common stocks (when averaged over 304 firms) can be explained merely by the added financial risk taken in by the underlying firm with its use of debt and preferred stock. Therefore, corporate leverage does impact considerably.

Lev (1974) concluded that the empirical results are indeed consistent with the hypothesized relationship. Empirical analysis indicated that the average variable cost component is negatively associated with the systematic risk measures for all three industries examined. The explanatory power of the variable cost component in terms of the coefficient of multiple determination, R^2, was modest. The evidence did not support the use of operating leverage as the only variable contributing to cross sectional risk differentials. Lev claimed that the poor performance of the variable cost measure with respect to the systematic risk of oil producers may be explained by the relative heterogeneity of this industry.

The empirical tests of the study of Hill and Stone (1980) supported a conclusion that changes in both financial structure and systematic operating risk are significant determinants of period-to-period changes in market betas. Hence, forecasts of future market betas can be significantly improved if one can predict future financial structure and operating risk.

Mandelker and Rhee (1984) claimed that the empirical results of their study were consistent with their postulate that the regression coefficients of DOL and DFL are consistently positive, suggesting that both are positively associated with the relative riskiness of common stock. The explanatory power of both operating and financial leverage was relatively high for these types of studies (ranging between thirty eight and forty eight percent).

Finally, Ismail and Kim (1989) found that the addition of either funds or cash flow based risk measures significantly improved the explanatory power of regression models which use an accrual earnings based risk measure. The major implication of the results of this study is that, within the confines of explaining market risk, the information in accrual earnings may be largely a subset of the broader set of information included in cash flows.

Overall, the literature review reveals that accounting based risk variables possess significant explanatory power over the cross sectional variation of market risk. Our study, which is an extension of this literature, examines the ability of accounting risk variables in explaining Arbitrage Pricing Theory risk measures. In the following chapter, we continue with the literature review of the Arbitrage Pricing Theory.

CHAPTER II

OVERVIEW OF ARBITRAGE PRICING THEORY

Introduction

Blaug (1968) writes that, "It takes a new theory and not just the destructive exposure of assumptions or the collection of new facts to beat the old theory."[1] In the context of this chapter, the Capital-Asset Pricing Model (CAPM) is the old theory. The studies of Roll (1977), and more recently, Fama and French (1992) expose the weaknesses of the CAPM. The Arbitrage Pricing Theory (APT) developed by Ross (1976), extended by Huberman (1982), and generalized by Chamberlain and Rothschild (1983), plays the role of the new theory, challenging the CAPM.

Blaug's quote serves as the outline of the chapter. More specifically, the chapter deals with the following issues: In part one, we review the criticisms of the CAPM. These criticisms were the prelude to the introduction of the APT. The second part examines the APT. More specifically, we discuss the theoretical model, its assumptions, implications, and criticism of the APT. The empirical implementation of the APT appears in part three. In part four, we evaluate the literature relating the APT risk measures with accounting, financial and economic variables.

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[1]Blaug (1968), p. 681.

1. Criticism of the Capital Asset Pricing Model

For several years, the CAPM and more specifically its beta measure of systematic risk, were the everyday tools for the investment community. At the same time, in the academic community numerous studies were conducted for the empirical implementation and the theoretical refinement of the model. The CAPM was challenged on theoretical grounds by Roll (1977), and more recently by the empirical findings of Fama and French (1992).

Roll challenged our ability to empirically test the CAPM. He argued that whenever we test the CAPM, we basically test the mean-variance efficiency of the market portfolio. In order to carry out tests of the CAPM, we need to know the exact structure of the market portfolio. Theoretically, the market portfolio contains all risky assets. It is an index of all risky assets on earth, and naturally, it is difficult to observe. This implies that the theory is not testable unless all individual assets are included in the sample. Therefore, we can not empirically test the CAPM.[2]

At the empirical level, the study of Fama and French (1992) claims that beta is not adequate in explaining stock returns. The following cite, from *The Economist* , is phrased in the same spirit as the quote from the Blaug that we used in the introduction of this chapter.

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[2]Roll's critique is more elaborate and deals with several other aspects such as the linearity of the relation between expected return-beta, and the use of a proxy for the market portfolio. When using market proxies such as the S&P 500 index, he argues that estimated betas actually measure S&P 500 related risk. Therefore use of a proxy, that is itself an inefficient portfolio, may cause incorrect separation of total risk.

> "A new paper by two Chicago economists, Eugene Fama and Kenneth French, explodes that model (CAPM) by showing that its key analytical tool does not explain why returns on shares differ."[3]

Fama and French argue that variables such as firm size and the ratio of book value to market value of equity have better explanatory power than market beta. There is no reliable relation between beta and average stock returns. In order to support their arguments, they create different portfolios ranked by book to market value, size, and beta. The difference between the returns of portfolios ranked by book to market value ratios were wider than any other type of ranking.[4]

Though not free of criticism itself, the APT is regarded as the natural alternative to the CAPM. Compared to the CAPM, the APT uses a set of simpler assumptions for its development. As far as the theoretical criticism on the testability of the CAPM is concerned, the APT does not require or use at any point the market portfolio.

In the following sections we provide an outline of the APT. We discuss the theoretical model, implications, and criticism of the APT.

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[3]This quote is from an article titled "Beta Beaten," *The Economist*, March 1992, p. 87.

[4]A recent study by Mei (1993) replicates in some way the Fama-French study using APT. He tests whether "a multi factor model such as the APT of Ross (1976), offer a comprehensive explanation of the cross-section average returns? That is, can the multiple betas from a multi factor model absorb the role of size and book to market equity so that asset returns are still determined ultimately by systematic risk instead of firm-specific variables? ... It is found that the model is capable of explaining the "size effect" and the "dividend yield effect", but is incapable of explaining the "book to market effect" and the "earnings price ratio effect." pp. 331-332.

2. The Arbitrage Pricing Theory

The APT, as developed by Ross (1976), assumes an economy with n-risky assets whose returns are generated by a strict k-factor (k < n) linear process of the form:

$$R_i = \bar{R}_i + \sum_{j=1}^{k} b_{ij} (F_j - \bar{F}_j) + e_i; \tag{2.1}$$

where,

R_i = the random returns on asset i,

$\bar{R}_i$ = the ex-ante expected return on asset i,

b_{ij} = the sensitivity of the i^{th} asset to changes in the j^{th} factor, which measures the asset's systematic risk,

F_j = the j^{th} common factor that affects the i^{th} asset's returns,

$\bar{F}_j$ = the expected value for the j factor,

e_i = a random idiosyncratic term with an expected value equal to zero and bounded variance.

All the error terms are assumed to be uncorrelated among themselves and uncorrelated with the common factors. It is also assumed that the expected value of the unanticipated changes of these factors from their mean will be zero, i.e.,

$E (F_j - \bar{F}_j) = 0$,

In simple terms (2.1) conveys that investors have formulated appropriate expected returns for each asset (ex-ante expected returns $\bar{R}_i$). The actual returns (R_i)

will deviate from what investors had expected due to the influence of unanticipated changes in certain pervasive economic and financial risk factors.

Assuming that there is an adequate number of assets in the economy so that we can create portfolios with zero investment (sum of weights equal to zero) and zero exposure to all pervasive risk factors, the expected return for this portfolio should be equal to zero. If the expected return for this type of portfolio is different than zero, arbitrageurs will buy or sell them in order to exploit this situation. As a result of arbitrage, the expected returns for these portfolios will gravitate towards zero.

We can summarize the previous argument using vector notation as follows:

Zero investment,

$$\sum_{i=1}^{n} w_i = 0 \tag{2.2}$$

and zero risk,

$$\sum_{i=1}^{n} w_i b_{ij} = 0, \quad j=1,\ldots,k \tag{2.3}$$

imply that the expected level of returns should be zero, i.e.,

$$\sum_{i=1}^{n} w_i \, \overline{R}_i = 0 \tag{2.4}$$

In other words, if the vector of weights *(w)* is orthogonal to a vector of 1s (as in 2.2), and orthogonal to the *k* vectors of risk sensitivities (as in 2.3) they will also be orthogonal to the vector of expected returns (as in 2.4). A well known theorem in linear algebra states that, if a vector is orthogonal to n vectors then the n^{th} vector can be expressed as linear combination of the other n-1 vectors. In our case, the n^{th} vector which is the vector of expected returns can be expressed as a linear combination of the vector of 1s and the vector of b_{ij}'s, i.e.,

$$\overline{R}_i \simeq \lambda_0 + \sum_{j=1}^{k} \lambda_j \, b_{ij} \tag{2.5}$$

where,

$\lambda_0 = R_f$, when risk free borrowing and lending is assumed, and

$\lambda_j = \overline{R}_j - R_f$ is the excess return (risk premium) on a portfolio exposed only to risk associated with the j economic factor, i.e., if $j=1$, then $b_{i1}=1$, and $b_{ij}=0$ for all $j \neq 1$.

Therefore, assuming a well diversified economy and utilizing the law of one price (no arbitrage opportunities), equation (2.5) gives the equilibrium relationship for any asset or portfolio. The APT does not specify either the number or nature of the factors generating asset returns or the sign or size of the associated risk premia.

The basic theme of the APT may be summarized as follows:

The actual security returns will depend on a variety of pervasive economic and financial risk factors, as well as firm or industry-specific influences. As pervasive risk factors, the literature on the APT names industrial production, inflation rate, the term structure of interest rates, and default risk premium. If these pervasive economic factors are anticipated, their influence will be incorporated by individual investors into the formation of the expected returns component of actual returns.

If economic and financial risk factors are unanticipated they will form the second component of an asset's actual return (second term on the right hand side of equation 2.1). Each one of the unanticipated changes in the economic/financial risk factors is multiplied by the corresponding sensitivity of the asset to this factor and added to the expected return component in order to determine the portion of actual returns which is explained by systematic factors in the economy.

The third and last component of asset returns (third term on the right hand side of 2.1) is determined by events that are not systematic in the economy as a whole. They are firm or industry-specific influences and they form the random, idiosyncratic component of actual returns. Their influence on asset returns can be minimized by diversification.

According to the APT the sensitivity of an asset's returns to unanticipated changes in the pervasive risk factors reflects the security's measure of systematic risk. The level of expected returns is a linear function of the sensitivity of actual returns to unanticipated changes in the pervasive economic factors. As a result, any set of two stocks or portfolios having the same systematic risk must have the same expected return. Every time that an asset or portfolio has an expected return not proportional to its risk level, arbitrageurs could step in and make a profit by buying assets with relatively high returns compared to their risk level, and selling those with relatively low returns compared to their risk level. Furthermore, given the linear association between expected returns and systematic risk, illustrated by 2.5, it is theoretically and empirically possible to create portfolios which hedge specific risk type, e.g., inflation, based on the investor's preferences.

Compared to the CAPM, the APT is more robust and requires fewer assumptions while it has the same intuitive appeal. The APT seems to possess an advantage over the CAPM on the following points:

> First, the description of the equilibrium in the APT is driven by the law of one price for substitute assets and is more general than in the CAPM based models which assume that only means and variances influence asset prices.
>
> Second, the APT allows more than just one or two pervasive factors to influence asset prices.
>
> Third, the APT makes no assumptions about the distributions of asset returns or the investor's utility functions.
>
> Finally, the market portfolio does not play any special role in the APT.

In spite of all these advantages, Shanken (1992)[5] - one of the most prominent critics of the APT - claims that based on the results of Shanken (1982), and Reisman (1992), "... there would appear to be no basis for the traditional view that the APT is a viable alternative to equilibrium asset pricing models like the Sharpe-Linter

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[5]This section is based on an outline of the criticism on APT found in Shanken (1992).

CAPM or the intertemporal model of Merton (1973)."[6] According to Shanken (1982), one of the major theoretical drawbacks of the APT is that in a well-defined strict factor model, any set of variables could serve as factors. Shanken summarizes his results in the following way:

> " First, equivalent sets of securities may conform to very different factor structures. Second, the usual empirical formulation of APT, when applied to these structures, may yield different and inconsistent implications concerning expected returns for a given set of securities."[7]

In some way, Chamberlain and Rothschild (1983) address Shanken's criticism. They show that we can obtain results similar to those of Ross (1976) by assuming an approximate factor structure. They utilized residual returns which are correlated across securities if the eigenvalues of the residual covariance matrix are bounded as the number of assets tends to infinity. This means that the assumption of an exact factor structure is very strict. APT will hold if returns conform to an approximate factor model.

In a more recent study, Reisman (1992) demonstrates that even with an approximate factor structure, APT is still susceptible to the line of criticism first introduced by Shanken (1982). Reisman demonstrates that, if an approximate factor structure for security returns exists, then virtually any set of variables which are correlated with the risk factors can serve as the benchmark in an approximate APT

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[6]Shanken (1992), p. 1570.

[7]Shanken (1982), p. 1134.

expected return relation. In addition, he shows that an approximation of the sort first derived by Ross (1976) still holds even if these variables account for only a trivial fraction of the common variation in security returns.

In spite of these criticisms, researchers have been very prolific developing new procedures for the empirical implementation of APT.[8] It seems that more and more people in the academic and investing community hold the view that "APT is a viable alternative to CAPM".[9] Shanken in his most recent published work on APT admits that, in spite of the criticism, " ... a casual glance at current finance text books (and some of the academic literature) suggests that this view is still widely held."[10]

3. Empirical Implementation of the APT

According to Kryzanowski and To (1983), the following four assumptions must be verified in order to ensure that the APT can be tested unambiguously using time series data. First, the mean vector and the variance-covariance matrix of security returns must be inter-temporally stationary. Second, it must be true that security returns are generated by an explicit underlying factor structure that contains at least one pervasive risk factor. Thirdly, this factor structure should be replicable (congruent) across asset subsets and time periods. Fourthly, the variance of security sensitivities to risk factors must be inter-temporally stationary.

[8]One of the most recent procedures, a semi-autoregression approach to the APT, was introduced by Mei (1993).

[9]Shanken (1992), p. 1570.

[10]Shanken (1992), p. 1570.

Empirical research has concentrated primarily on the testing of the second and third assumptions. Two general procedures have been used in the previous research to implement APT. The first one employs statistical analysis to identify the number of risk factors in the generating process and then tests whether or not a given factor is priced. The second approach relies on basic economic arguments to pre-specify the risk factors and then tests the significance of the risk factor surrogates which are represented by macro-economic and/or financial variables.

3.A. Empirical Implementation of the APT using Statistical Analysis

Factor analysis is the oldest statistical procedure used for the empirical implementation of the APT. Although use of the factor analysis approach was first introduced by Gehr (1975), it is the work of Roll and Ross (1980) which is considered the *locus classicus of this literature*.[11] The center of interest in these types of studies evolves around the following question: What is the number of common risk factors in the asset return generating model? The answer to this question is crucial for the APT. If the number of factors is small - only one factor - the APT may not differ from CAPM. On the other hand, if the number of factors is too large, the practical use of the model could be trivial.

Roll and Ross (1980) examined daily stock returns for 42 groups of 30 stocks over the 1962-1972 period.[12] Utilizing maximum likelihood factor analysis they

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[11]Dhrymes, Friend and Gultekin (1984), p. 345

[12]The selection criterion that they used was an alphabetical listing of securities listed on the New York stock Exchange and American Stock Exchange. See Roll and Ross (1980), p. 1086.

estimated a five factor APT model for each one of the 42 groups. The Chi-Square statistic was used to test the null hypothesis that no more than five risk factors are necessary to explain daily returns. Interpreting the p-values associated with the test statistic as the probability that the five factors are sufficient, they claim that for 16 out of the 42 groups there was a greater than 90% chance that five factors were sufficient. In more than 75% of the groups there was at least a 50% chance that five factors were sufficient.

Kryzanowski and To (1983) used monthly data for 11 groups of 50 securities in order to test the assumption that security returns are generated by a linear factor structure that contains at least one common factor. The authors employed both Rao and Alpha factor analysis with US and Canadian data. In alpha factor analysis, they determined the number of relevant factors by calculating how many factors had positive generalized coefficient. They found that while the first factor had perfect generalizability, that attribute disappeared rapidly from the second factor onward. In Rao's factor analysis, the relevant number of factors was determined by calculating the Chi-square statistic. For the US data, it appeared that at least ten factors were relevant in the factor structure of security returns.

Besides these, Kryzanowski and To introduced one more criterion in order to ensure that non-trivial factors would not be retained. This criterion required that " ... the marginal retained factor should have at least as much explanatory power as a single variable. Thus, for a 50-factor model, the common variance accounted for by the marginal factor should be at least 2 percent."[13] Based on a scree plot representing the percentage of common variance accounted for by each factor, they concluded that factors beyond the fourth or the fifth one lay on the flat gradient. This was interpreted as an indicator that, even if the Chi-square test indicated a minimum of ten relevant factors in the factor structure; factors of higher order, whether trivial or non-trivial were not general.

The results of the Roll and Ross study were challenged by the study of Dhrymes, Friend and Gultekin (1984). They re-examined the sample specified by Roll and Ross (1980) and failed to substantiate their findings. The authors claimed that the division of the sample by Roll and Ross into smaller groups might ignore other substantial sources of co-movements between the securities of separate groups. In addition, the factors which were identified in one group might not be the same as the factors identified in some other group. Dhrymes, Friend and Gultekin showed that the number of significant factors increase with an increase of either the size of the sample, or the number of days in the sample. This implied that the factor structure was not replicable across subsets and time periods. According to Kryzanowski and To (1983) this was one of the assumptions that must be verified in order to ensure that the APT can be tested.

All previous reported studies have something in common, they use factor analysis, and more specifically, maximum likelihood factor analysis. But this approach suffers from two limitations. First, it requires an exact factor structure in

[13]Kryzanowski and To (1983), p. 39.

which the unique factors - residual components of returns not explained by the factors - are uncorrelated across securities.[14] The second constraint is that in factor analysis (with the exception of principal factor analysis) the factors are unique only up to rotation. The fact that there is a certain indeterminacy associated with this lack of identification is the chief barrier against finding a significant economic interpretation of the results of factor analysis in this context.

Instead of assuming an exact factor structure, Chamberlain and Rothschild (1983) proposed an approximate factor structure. They showed that we could obtain results similar to those of Ross (1976) by working with residual returns which were weakly correlated across securities. Chamberlain and Rothschild showed that if k eigenvalues of the population covariance matrix increase without bound as the number of securities in the population increases, then the elements of the corresponding k eigenvectors - the weights in the principal components- of the covariance matrix can be used as the factor sensitivities. The implication of this study was that principal component analysis might be sufficient to empirically test APT. This conclusion was crucial since in principal component analysis the approximate factor structure is unique. Conor and Korajczyk (1988) extended this finding and showed that it also holds for the sample covariance matrix.

Conor and Korajczyk (1988) tested the APT using the asymptotic principle components theory suggested by Chamberlain and Rothschild (1985). They found

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[14]Harman (1976), p. 21.

that a five factors version of APT can explain the persistent size related seasonal effects in asset pricing better than the value weighted CAPM.

The principal component approach for testing the APT was also used by Trzcinka (1986). He focused his empirical research on the number of factors in the APT. According to Chamberlain and Rothschild (1983), the stock returns would be linearly associated to a *k*-factor model if, and only if, the *k* eigenvalues of the covariance matrix of returns become larger and larger as we more and more securities are added in the sample. Trzcinka used this argument to test for the number of factors in APT as follows; if a *k* factor model generates asset returns then the number of eigenvalues which are exploding - as the number of securities included in the covariance matrix increases - must be constant and equal to *k*.

Using weekly returns for all firms listed on the 1983 CRSP tapes, Trzcinka created a sequence of samples containing increasing numbers of securities. The largest sample contained 865 securities. For each one of these samples, Trzcinka calculated the sample covariance matrix which was subsequently used to estimate the eigenvalues. Analysis of the sequence of the estimated eigenvalues led to the following conclusions. The first eigenvalue (the largest as a percentage of the variance of the return) converges to a constant - a property not possessed by any other eigenvalue. The second through fifth eigenvalues were the only eigenvalues which continued to grow with the number of securities in the sample. The author concluded that while there may be many factors responsible for security returns, one factor appears to be more important than the rest.

Brown and Weinstein (1983) used the bilinear paradigm to test the APT. Their approach was based on a constraint that applies to all equilibrium asset pricing models. This constraint required that all priced risk premia were common across securities. Thus, if there are any differences observed across groups of securities, these differences must not be statistically significant. The authors argued that statistically significant differences would indicate that the theoretical model was inconsistent with the data. They implemented the test using the data set of Roll and Ross (1980) and found that the data were in apparent conflict with the model of five or seven factors. However, when they made adjustments for the size of the test , their results were consistent with the three factor APT. In addition, they continued to reject the 5 and 7 factor versions - a finding that actually added support to the three factor model.

Erhardt (1987) showed that the maximum likelihood chi-squared tests used in previous empirical studies of the APT are inappropriate, inflating the number of significant factors in the model. The appropriate/required number of risk factors in the asset return generating model can be tested in accordance with the following argument: a model contained the correct number of factors if, and only if, the estimated residuals for each security had a mean which was not statistically different than zero. Erhardt used Hotteling's multivariate T^2 statistic to test the postulate. The author concluded that in the asset return generating model only one factor was required; that is, a model using only one risk factor was producing residuals for each security that were not statistically significant different than zero.

Conway and Reinganum (1982) used cross validation in order to identify a stable factor structure in security returns. Cross validation uses two random samples; the first one to estimate the model, and the second to validate the predictions. The identification of a stable factor structure is based on the following criterion: the prediction error for models with too many factors (overfit models) begins to stabilize or increase as we add more factors in the model.

Conway and Reinganum's findings are summarized in the following points. First, unlike the previous studies which, based on the likelihood ratio test, concluded that the number of factors increases with the number of securities in the sample, cross validation identified the existence of one dominant and another minor factor. Second, even with controlled samples cross validation identified a stable factor model with one dominant factor and two minor ones.[15]

Chatterjee and Pari (1990) used a bootstrap approach to answer the old question: 'What is the number of factors in the stock-return generating process?' The authors applied the bootstrap method on a sample similar to that of Roll and Ross (1980). Based on their empirical results, the authors claimed that only one factor was significant in the return generating process. In addition, the number of significant factors did not increase with the number of stocks in the sample.

Conor and Korajczyk (1993) tested for the number of factors in APT in the context of an approximate factor structure. They developed a test statistic which was based on the following argument; if the correct number of pervasive risk factors is k,

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[15]Controlled samples contained groups of securities that explicitly incorporate results of previous studies about the industry and size effect

then we should not expect a statistically significant decline in the cross sectional mean error terms as we increase the number of factors in the model. They applied their test to a sample of stocks traded on either the New York stock Exchange or the American Stock Exchange for the period 1967 to 1991. Given the importance and uniqueness of returns corresponding to the month of January, they compared the results with and without January. When the sample included the month of January, the results indicated that up to six factors might be needed to describe security returns. For the sample that did not contain the January returns, the test indicated that one or two factors were sufficient. The authors argued that overall the appropriate model might contain three to six factors.

A new approach to test APT was introduced by Mei (1993a). Mei demonstrated that historical stock returns could be used to approximate the unobservable factor loadings. This having being done, he transformed the original k-factor model into a k-lag autoregressive model that was used to estimate the risk factors. Mei (1993b) tested for the correct number of factors in APT according to the following argument: if k is the correct number of risk factors in the asset return generating model, then k lags should be sufficient to describe asset returns.

In order to test this hypothesis Mei estimated the following autoregression model, for the period 1981 through 1990,

$$\begin{bmatrix} R_{it} \\ \cdot \\ \cdot \\ \cdot \\ R_{Nt} \end{bmatrix} = \begin{bmatrix} 1 & R_{1,t-1} & \cdot & \cdot & \cdot & R_{1,t-k} \\ \cdot & & & & & \\ \cdot & & & & & \\ \cdot & & & & & \\ 1 & R_{N,t-1} & \cdot & \cdot & \cdot & R_{N,t-k} \end{bmatrix} * \begin{bmatrix} \psi_{0t} \\ \cdot \\ \cdot \\ \cdot \\ \psi_{0k} \end{bmatrix} + \begin{bmatrix} n_{it} \\ \cdot \\ \cdot \\ \cdot \\ n_{Nt} \end{bmatrix}$$

where t=k+1, ... T.

Mei mentioned that although the estimated model looks like a seemingly unrelated model (SUR), this system is a set of cross-sectional regressions for different time periods instead of the conventional set of time series regressions for different individuals.

Using COMPUSTAT data from 1972 through 1990, Mei estimated the autoregression coefficients for lags ranging from three to seven years. Mei found that the autoregression coefficients up to the fifth lag were statistically significant. This result was interpreted as indicative of there being at least five systematic factors in asset returns generating models. Furthermore, the analysis shows that the contribution of additional factors in the explanation of cross sectional variation of returns was statistically insignificant.

3.B. Empirical Implementation of APT Using Pre-Specified Factors

Empirical implementation of the APT using pre-specified economic factors has been carried out by Chen, Roll and Ross (1986), as well as in several other studies. A brief review of some of the more relevant studies is presented below.

Chen, Roll and Ross [CRR] argued that changes in term structure and risk premium affect the risk adjusted discount rate - the denominator in the traditional discounted cash flow formula. On the other hand, changes in real and nominal forces, such as changes in industrial production and unanticipated inflation, influence the expected net cash flows - the numerator of the valuation formula. Based on this, the authors hypothesized that asset returns could be explained by unanticipated changes in the following four factors: 1. inflation; 2. industrial production; 3. default risk premia; and, 4. the term structure of interest rates.

CRR examined the importance of these state variables over the 1958-84 period, as well as the sub periods 1958-67, 1968-77, and 1978-84 using a technique that resembled the Fama-McBeth (1973) approach. CRR described their technique as follows:

> "...(b) The assets' exposure to the economic state variables was estimated by regressing their returns on the unanticipated changes in the economic variables ... (c) The resulting estimates of exposure (betas) were used as the independent variables in 12 cross-sectional regressions, one regression for each of the next 12 months, with asset returns for the month being the dependent variable. ... (d) Steps *b* and *c* were then repeated for each year in the sample, yielding for

each macro variable a time series of estimates of its associated risk premium. The time-series means of these estimates were then tested by a *t*-test for significant difference from zero.[16]"

When testing the entire sample period, they found that the monthly growth rate of industrial production, unanticipated inflation, and default risk premia were significant at 10%, and that unanticipated change in term structure was significant at 20%. The results for the three sub-periods were weaker.

In a similar study, Burmeister and Wall (1986) used the following macroeconomic variables: 1. unexpected change in default risk premia; 2. unexpected change in term structure; 3. unexpected inflation; and, 4. unanticipated change in the growth rate of real final sales. They utilized Kalman filter techniques to develop improved estimates for unexpected inflation and unanticipated change in the growth rate of real final sales. Using a methodology similar to the CRR's, they ran time series regressions on three alternative portfolios and found that with few exceptions their macroeconomic variables were all significant in explaining realized portfolio returns.

McElroy and Burmeister (1988) estimated a nonlinear regression model of monthly stock returns on macro-economic variables. They found that risk factors associated with: 1. changes in default risk premia; 2. changes in the term structure of interest rates; 3. unanticipated inflation or deflation; 4. unanticipated changes in the

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[16]CRR (1986), p. 394.

growth rate of sales; and, 5. a residual market risk, were all significant in explaining realized and expected returns.

Berry, Burmeister, and McElroy (1988) extend the previous work of McElroy and Burmeister (1988), attempting to identify and estimate the risk sensitivities corresponding to these five pervasive macro-economic and financial risk factors over various economic sectors and industries. The empirical results reported by McElroy and Burmeister (1988), support their argument that APT risk sensitivities vary considerably both across economic sectors and across industries.

Chen and Jordan (1993) investigated the ability of two APT based models to predict portfolio returns over the period 1971-1986. The first model , called the factor loading model (FLM), relied on factor analysis for the estimation of factor betas and the associated risk premia. The authors used maximum likelihood factor analysis to derive the factor loadings (betas), prespecifying the number of factors to be five. The factor scores were subsequently derived using Bartlett's (1937) procedure. The second model, named the macroeconomic variable model (MVM), relied on prespecified innovations in a set of macrovariables. The authors selected the same macroeconomic variables that were suggested and used in the study of CRR (1986). Chen and Jordan tested the ability of the two models to explain the cross sectional variations in returns for industry portfolios in an original sample, as well as for an equally weighted portfolio in the holdout sample, and to predict *ex ante* security returns.

Although the FLM outperformed the MVM in all three tests, the superiority was only marginal. The authors concluded that little was lost in moving from the FLM to the MVM. Chen and Jordan argued that a different set of macrovariables or simply better measures of the variables that were used in their study might have been able to improve the performance of the MVM.

4. Association Between APT Risk Measures and Accounting Variables

Young et al. (1987) and (1991) investigated the usefulness of accounting data in predicting APT factor risks. They found that APT beta coefficients, predicted by a set of accounting variables, outperformed a set of forecasts based on historical betas.

Using a sample of 252 S&P firms, Young et al. estimated the APT factor sensitivities for the following four factors: 1. unexpected change in risk premium, (UPR_t); 2. unexpected change in the term structure of the interest rates, (UTS_t); 3. unexpected inflation, (UI_t); and, 4. unexpected change in the growth rate of final sales, (UGS_t).[17] In other words, they estimated the following measures of systematic risk - β_{UPR}, β_{UTS}, β_{UI}, and β_{UGS} - for each company as a function of a set of accounting variables:

$\beta_{factor\ i} = f($ Payout, asset growth, leverage, size, liquidity, and earnings variability. ROI, cash position, capital intensity, short term liquidity, receivables, inventory, debt, and cash flow)

[17]These factors were introduced by Burmeister and Wall (1986).

The highest explanatory power that they reported was 17.6 per cent, and it was for the beta corresponding to unanticipated inflation (UI) . The lowest explanatory power was 5.4 per cent, and it was for the beta corresponding to growth of sales (UGS). Comparison of estimated β's for the next period from these models with the naive predictions, as well as Bayesian adjusted beta estimations, indicated that the accounting model outperforms the naive one but not that of the Bayesian adjusted betas.

McGowan, Etebari and Horrigan [MEH] (1991) examined the hypothesis that APT risk measures are linearly associated with firm characteristics. They used principal component analysis to estimate the APT risk measures. The empirical analysis supported the existence of five pervasive risk factors and their estimated sensitivities were used to test for the association. Their set of explanatory variables included the following nine financial accounting variables: 1. total debt to total assets; 2. current assets to current debt; 3. sales to accounts receivable; 4. sales revenue; 5. fixed assets per employee; 6. cost of goods sold to inventory; 7. net operating income to assets; 8. net income to sales; and, 9. cash to cost of goods sold and other expenses.

MEH tested their hypothesis using canonical correlation as well as stepwise regression analysis. Canonical correlation indicated that linear combinations of accounting variables were significantly correlated with linear combinations of APT sensitivities. Regression analysis indicated that linear combinations of accounting variables could explain significant portions of the variability of APT risk measures.

Regression models using financial ratios explained up to 73% of the variability of the second APT risk measure. For the rest of the APT risk measures, the R^2 ranged from 7 to 19%. Overall, they found that the size of a firm was an extremely significant explanatory variable.

They suggested that future research on the association between APT risk measures and firm characteristics should concentrate on finding supporting evidence from other time periods and using a more extensive set of financial ratios. This research caries out such a study.

CHAPTER III

THE THEORETICAL MODEL AND THE DATA SET

The major emphasis of this study is empirical analysis of the following question: Can we use traditional accounting risk measures from the current period to explain the cross sectional variation of the Arbitrage Pricing Theory (APT) risk measures in the next period?

In this chapter, the outline of the theoretical model and a detailed description of the data set are presented. The chapter is organized as follows: in part 1 the theoretical model is presented; in part 2, the criteria used for forming the sample are described; and in part 3, the explanatory variables, that is, the traditional accounting risk measures (TARMs), used in the empirical analysis are described. This section also includes a discussion of the theoretical association between the TARMs and risk, as well as a discussion of the limitations of using financial accounting variables. In part 4, the dependent variables, i.e., the APT risk measures (betas), are described. Also presented here is the empirical evidence supporting the existence of cross sectional variation for the estimated betas in the study. Finally, the chapter closes with some comments regarding the properties of the data set and with a presentation of the tested model in matrix form.

1. The Theoretical Model

According to the APT model, stock returns are generated by a multi-factor linear process, as follows:

$$\tilde{R}_i = E(R_i) + \sum \beta_{ij} (\tilde{F})_j + \tilde{\epsilon}_i, \qquad (3.1)$$

where,

$\tilde{R}_i$ = the stock returns for the i^{th} security,

$E(R_i)$ = the expected returns for the i^{th} security,

$\tilde{F}_j$ = the value for the j^{th} pervasive risk factor[1], "pervasive" in the sense that its influence is across all securities,

β_{ij} = the slope coefficient, measuring the sensitivity of the *i* security to unanticipated changes of the j^{th} factor, and

$\tilde{\epsilon}_i$ = the security specific component of stock returns, with means and correlations of zero and bounded variances[2] per the assumptions of the model.[3]

We extract beta estimates (b's) for this model (equation 3.1) using factor analysis. For the estimated betas, we assume that,

$$E(b_{ij}) = \beta_{ij}, \qquad (3.2)$$

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[1] Pervasive risk factors are not observable and their number is not specified in APT.

[2]The variances are not necessarily equal.

[3]See Huberman (1982), p. 184.

Since the APT does not specify the nature of the risk factors, it is difficult to explain or interpret the estimated risk factors. The assumption that we make and test in this study is that each one of the APT risk measures can be expressed as a linear function of certain TARMs, i.e.,

$$\beta_{ij} = \sum_{1}^{P} \gamma_{ip}(TARM_{ip}) \tag{3.3}$$

Since the true betas (β's) are not observable, we use the estimated coefficients (b's) in order to examine the validity of the previous assumption, based on the following model:

$$b_{ij} = \sum_{1}^{P} \delta_{ip}(TARM_{ip}) \cdot \tag{3.4}$$

Equation (3.4) is used to examine the issue raised at the beginning of the chapter. That is, we use estimated betas from period *t* and accounting data from *t-1* in order to explain the fluctuations of a firm's risk sensitivity (β) over time.[4]

2. Sample Size

This study uses financial accounting and stock return data for a sample of 373 manufacturing companies, i.e., firms having two digit Standard Industrial Classification (SIC codes) between 20 and 39, inclusive.

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[4]Alternatively, this study could be used to provide evidence for answering the following questions: What are the possible underlying factors that cause a firm's APT risk sensitivities to fluctuate with time? What are the factors that may be used to explain the cross sectional variation of APT risk measures? For example, using contemporaneous information for the estimated betas and accounting risk measures, we can apply regression analysis on (3.4) in order to explain the cross-sectional variation of the APT risk measures.

To be included in the sample, a firm had to meet the following criteria:

1. A manufacturing company having an SIC between 20 and 39;

2. Listing on CRSP tapes with daily stock return data available for the period 1984 to 1986;

3. Listing on COMPUSTAT tapes with financial accounting data available for 1983; and,

4. Conformance with constraints imposed by the definitions used in the creation of certain TARMs.

We found 1047 manufacturing companies listed in the COMPUSTAT tapes. The process began with extraction of data for the financial accounting variables from COMPUSTAT because it was suspected that the number of companies with missing data in COMPUSTAT was larger than those with missing data on the CRSP tapes. At this point, availability of data in COMPUSTAT tapes was the binding constraint.

The data for the accounting variables were extracted from COMPUSTAT for 1983. Some of the TARMs required accounting data from 1982, 1981, 1980 and 1979 as well. The accounting variable data set was cleaned of firms with missing values in COMPUSTAT. It was found that 537 companies had missing data, so they were dropped from the sample. For certain TARMs, expressed in the form of a ratio, a negative value in the numerator, or the denominator, or both, may lead to rather erroneous results.[5] Furthermore, TARMs in ratio form must have a

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[5]"Analysis of ratios that have negative numerator or denominator is meaningless and the negative sign of the ratio should simply be noted." Gibson (1989): 139.

"... a firm with negative net worth will show a negative ratio (return on net worth) when profits are positive and, even more ridiculous, a positive ratio when both net worth and profits are denominator different than zero. As a result of the constraints imposed by these criteria, we ended up with financial accounting data for a sample of 444 manufacturing entities listed in COMPUSTAT files.

The next step was to extract daily stock return for this sample for the period 1984-1986 from the CRSP files. Missing data were encountered for 71 firms. As a result, those firms were also excluded from the sample. The final sample contains 373 companies. This sample is broad in the sense that it contains companies representing all the segments of the manufacturing industry as shown in Table 3.1.

3. Traditional Accounting Risk Measures

3.A. Definitions and Theoretical Relation with Risk.

The traditional accounting approach to measurement of risk relies on financial statement analysis. In the definition of financial statement analysis, we find that one of its objectives is to identify major changes in financial accounting data and use them as signaling "an early warning of a significant shift in the future success or failure of a business."[6]

Among the various techniques utilized in financial statement analysis, we concentrate primarily on financial accounting ratios. Hence, we identify most of our accounting risk measures with financial ratios. As these ratios possess desirable

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negative." Altman (1988): 45-46.

[6]Gibson (1989):120

TABLE 3.1

Companies in the Sample

SIC Code	Short Title	Number of Companies
20	Food and Kindred Products	28
21	Tobacco Products	2
22	Textile Mill Products	13
23	Apparel and other Textile	10
24	Lumber and Wood Products	4
25	Furniture and Fixtures	6
26	Paper and Allied Products	19
27	Printing and Publishing	16
28	Chemicals and Allied Products	53
29	Petroleum and Coal Products	14
30	Rubber and Misc. Plastic Products	11
31	Leather and Leather Products	7
32	Stone, Clay and Glass Products	6
33	Primary Metal Industries	9
34	Fabricated Metal Products	19
35	Industrial Machinery and Equipment	39
36	Electronic and Other Equipment	49
37	Transportation Equipment	31
38	Instruments and Related Products	29
39	Miscellaneous Manufacturing Industries	8

properties, there is already a rich literature connecting them with risk.[7]

In Horrigan (1968) we find that the use of financial statement analysis dates back to the previous century. Ratios were first introduced in credit analysis and managerial accounting. The current ratio was introduced during the last decade of the nineteenth century as a measure of a borrower's ability to meet interest obligations and repayment of principal. Around 1919, the DuPont company introduced its "triangle" system in order to evaluate its operating performance.[8]

Whittington (1980) identifies two uses for financial ratios, a normative and a positive one. Used in a normative sense, the ratio is compared to its past performance or industry standards. In a more positive approach, the ratio is used to predict or assess certain variables. Accountants, managers and investors may use a ratio to predict the future value of one of its components. Also a ratio may be used to predict other variables such as bond ratings,[9] or the incidence of corporate failure,[10] as well as aiding in the assessing of risk. Positive applications of these ratios in prediction of other variables is the primary interest in this study.

The classification of financial accounting risk measures such as ratios and variables is not clear because the boundaries vary among authors. Ratios which one

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[7]For the purposes of this study 'ratio' refers to accounting ratios, and 'variables' refers to information derived from financial statements.

[8]DuPont's triangle system was comprised of three ratios: profits to total assets, profits to sales and sales to total assets.

[9]Selectively we refer to the works of Belkaui (1983), Melicher and Rush (1974), and Horrigan (1966).

[10]Selectively we refer to the following works: Altman (1984 and 1986), Beaver (1966 and 1968), Santomero and Vinso (1977), and Zavgren (1980 and 1985).

author classifies in one category are presented in another category by others. In our analysis, we decided to use the simple text-book type classification and presentation of these ratios. In other words, we classify them based on their context or use.

A. Liquidity Ratios. These ratios are designed to capture the ability of an entity to meet its short-term obligations and to use its liquid assets efficiently. Liquidity ratios measure those abilities by relating a firm's current liabilities, such as accounts payable, to current assets, such as cash, short term investment, accounts receivable, and inventory. They are important for a company because even a profitable firm may be forced to bankruptcy if it cannot meet its short term financial obligations. In general, a low liquidity position can lead to greater financial distress, so lower liquidity implies higher risk both for creditors and investors.[11]

One of the oldest ratios reflecting the ability of an entity to meet its short-term obligations is the current ratio (CR), which is derived by dividing a firm's current assets by its current liabilities.[12]

$$Current\ Ratio = \frac{Current\ Assets}{Current\ Liabilities}.$$

[11]Until the mid sixties the rule of thumb for the current ratio suggested a value of 2.00 or above. The minimum value for the quick ratio also known as the acid ratio, of a successful company was 1.00. This guideline lost its power after the mid sixties. Firms today do not follow the 2.0 and 1.0 rules. The trend of current ratio indicates a decline of liquidity of firms over time.

[12]See S. W. Lemke, "The Evaluation of Liquidity: An Analytical Study," Journal of Accounting Research (Spring 1970), pp. 47-77, for an in depth analysis of the liquidity and more specifically on the pros and cons of the current ratio.

If a more stringent measure of liquidity than the current ratio is desired, the quick ratio (QR) may be used. This ratio compares the more liquid assets (cash plus short term investments plus accounts receivable) to current liabilities.

$$Quick\ Ratio = \frac{Quick\ Assets}{Current\ Liabilities}.$$

The cash liquidity ratio is an indicator of the immediate liquidity of the firm. This does carry a significant weight in financial statement analysis, especially when the company is in financial straits. The cash ratio (CASH) is defined as follows

$$Cash\ Ratio = \frac{Cash + Short\ Term\ Investments}{Cost\ of\ Goods\ Sold}.$$

Another liquidity ratio is the working capital turnover (WCTOV).[13]

$$Working\ Capital\ Turnover = \frac{Sales}{Average\ Working\ Capital}.$$

Obviously, this ratio is intended to measure the effectiveness with which a company uses its working capital to support sales. A comparatively higher working capital turnover may indicate a more profitable use. If this is true, it is expected that this ratio would be negatively related to risk.

Liquidity of a company's accounts receivable is measured by the accounts receivable turnover in days. This ratio is also known as the average collection period (COLPERD).

[13]We introduce average working capital in the denominator because this ratio combines balance sheet information (working capital), with income statement information (sales). Working capital may not be representative of the whole year. We have decided to take the average figure of two successive years.

$$Average\ Collection\ Period = \frac{Average\ Accounts\ Receivable}{Net\ Credit\ Sales\ per\ Day}.$$

An increase in the average collection period may indicate lack of control over accounts receivable; and, hence, a weakening in the ability of the firm to meet its short term obligations. Therefore, a positive relation with risk is implied.

A large subset of liquidity ratios contains inventory ratios. The first of them is inventory turnover (INVTOV) defined as:

$$Inventory\ Turnover = \frac{Cost\ of\ Goods\ Sold}{Average\ Inventory}.$$

When the inventory is relatively small compared to the cost of goods sold, the inventory turnover will be high. This in turn implies that a relatively small inventory can support a large volume of sales. High values of the inventory turnover ratio also mean that inventories are used efficiently and are more liquid, implying that the firm is less risky.

The following ratio combines information about accounts receivable (AR), inventory (INV), and accounts payable (ACPAY). The ratio is Day's Resources Tied in Working Capital (DRTINWC), defined as follows:[14]

$$DRTINWC = \frac{INV}{\frac{Cost\ of\ Goods\ Sold}{365}} + \frac{AR}{\frac{Sales}{365}} - \frac{ACPAY}{\frac{Purchases}{365}}.$$

[14]A similar ratio was introduced by Richards and Laughlin (1980), "A Cash Conversion Approach to Liquidity Analysis," *Financial Management*, Spring, 32-38.

An increase in the number of days that resources are tied up in working capital may indicate a decline in the liquidity of the entity and therefore higher risk.

Inventory is the least liquid component of the current assets.[15] The next two ratios, Inventory to Current Assets (INVTOCA) and Inventory to Working Capital (INVTOWC), compare inventories with current assets and working capital.

$$Inventory\ to\ Current\ Assets = \frac{Inventory}{Current\ Assets}.$$

$$Inventory\ to\ Working\ Capital = \frac{Inventory}{Working\ Capital}.$$

An increase in the value of these ratios implies that the current assets and working capital are less liquid. As a result, the firm may become riskier.

B. Leverage Ratios. These ratios indicate an entity's ability to meet its long-term debt obligations. Two conditions are important in regard to a company's long-term debt paying ability: its profitability and the value of debt relative to its size. Profitability is important because it will indicate the ability of the entity to generate funds towards the repayment of both the principal and accrued interest of the debt.[16]

The proportion of debt to assets or capital of the firm is important because it bears a direct, positive relation with the volatility of earnings available to the common

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[15]Remember that quick assets may be defined as current assets minus inventory.

[16]Profitability ratios will not be presented here because we have the next section named profitability ratios.

equity holder, and therefore, risk.[17] A high proportion of a firm's funds provided by fixed debt obligations may imply a transfer of the burden of risk from owners to lenders.

The Total Liabilities to Total Assets ratio (TLTOTA), also known as the debt ratio, can be viewed as an indicator of the percentage of assets that were financed by creditors.

$$Total\ Liabilities\ to\ Total\ Assets = \frac{Total\,Liabilities}{Total\ Assets}.$$

The Total Liabilities to Shareholders' Equity (TLTOE) expresses the total liabilities as a percentage of the funds provided by owners.

$$Total\ Liabilities\ to\ Equity = \frac{Total\ Liabilities}{Equity}.$$

Both of these ratios are used to determine how well creditors are protected if the firm proves to be insolvent. As a general rule of thumb, the lower these ratios are, the better the firm's position. With a lower ratio, creditors will feel well protected and so the entity will be in a favorable position if additional long term debt is required.

Times Interest Earned, or Interest Coverage (COVERAGE), is defined as the ratio of earnings before interest and taxes over the interest expense on long term debt.

$$Coverage = \frac{Earnings\ before\ Interest\ and\ Taxes}{Interest\ expense\ on\ Long\ Term\ Debt}.$$

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[17]See Modigliani and Miller (1958) and Shalit (1975).

A high interest coverage ratio indicates that the firm will be able to meet its payment of interest on debt.[18] Obviously, higher values of this ratio are associated with lower financial risk.

Debt to Net Fixed Assets (DTONFXAS) is the last in the series of ratios used as indicators of a firm's ability to meet its long term obligation.

$$Debt\ to\ Net\ Fixed\ Assets = \frac{Debt}{Net\ Fixed\ Assets}.$$

Debt to net fixed assets indicates the extent to which debt has been used to finance net fixed assets. A lower ratio is always preferred.

An implication in all of the previous ratios is that the firm can use the funds provided by creditors in a profitable way, so that it will derive a return in excess of that needed to cover the interest on debt. In other words, we assume that the borrowed funds will be used to finance projects with a positive net present value.

C. Profitability/Efficiency Ratios. These ratios are important to stockholders, creditors and managers of an entity. Profitability ratios are the indicators of a firm's ability to generate cash flow directed towards stockholders in the form of dividends, and towards creditors in the form of interest and principal.

Profitability ratios expressing a firm's earning ability to control expenses are as follows:

[18]Some authors suggest the use of the one minus the inverse of the coverage ratio. This measures how much earnings must decline in order to bring the entity to break even point coverage of its long term debt obligations. A decline may imply an increase in the financial coverage and therefore, an increase in the financial risk of the company.

$$Gross\ Profit\ Margin = \frac{Gross\ Profits}{Sales}.$$

$$Net\ Profit\ Margin = \frac{Net\ income}{Sales}.$$

For both of these profit ratios, gross profit margin (GRSMRG) and net profit margin (PM), higher values are always more desirable.

Return on total assets (REOTA)[19] and return on common equity (REOE) comprise the set of ratios measuring the profitability and efficiency of an entity in relation to the assets and the equity capital employed, respectively.

$$Return\ on\ Total\ Assets = \frac{Net\ Income}{Total\ Assets}.$$

$$Return\ on\ Common\ Equity = \frac{Net\ Income - Dividend, Preferred}{Common\ Equity}.$$

The higher the values of these ratios, the more profitable/efficient the firm is. Therefore, the default risk for a company with large values of these ratios will be smaller.

Total assets turnover (TATOV) is another measure of firm's efficiency. It is defined as

$$Total\ Assets\ Turnover = \frac{Sales}{Total\ Assets}.$$

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[19]Return on total assets can also be expressed as the product of the Net Profit Margin and Total Assets Turnover. When return on total assets is examined using the latter formula, it is known as the DuPont Return on Assets.

This ratio bears an inverse relation with risk.

Net Fixed Assets Turnover (NFXASTOV) is a measure of a firm's ability to generate revenue through the productive use of its net fixed assets.

$$\textit{Net Fixed Assets Turnover} = \frac{\textit{Sales}}{\textit{Net Fixed Assets}}.$$

Intuitively, a higher turnover implies a less risky entity.

The last ratio is the Expenses to Revenue (EXPTOREV) ratio, which expresses the before tax expenses as a percentage of revenues.

$$\textit{Expences to Revenue} = \frac{\textit{Expenses before Tax}}{\textit{Sales}}.$$

A percentage value for this ratio above 100% indicates that the company does not generate any profits. This ratio is assumed to be positively related to risk.

D. Business Risk Related Ratios. These ratios reflect the sensitivity of a firm's operating earnings to fluctuations of the economy. Higher business risk is measured by higher volatility of operating earnings, which in turn implies that both owners and creditors will be uncertain about future dividends and debt repayments.

Business risk is measured by the variability of operating earnings defined as follows:

$$\textit{Variability of Earnings} = \frac{\textit{Standard deviation of Earnings}}{\textit{Average Sales}}.$$

The volatility of a firm's operating earnings can be attributed to two major components; variability of sales and operating leverage. The sales' volatility is related to the nature of the company's operations. Companies can be classified into three broad groups based on their relationship to the economy: cyclical, noncyclical and counter cyclical. Overall, sales of cyclical companies tend to fluctuate more than the economy, sales of non cyclical companies tend to be unaffected by changes in the economy, and counter cyclical companies experience sales' cycles which are opposite to business cycles.

The measure of sales uncertainty that we introduce in our study is the coefficient of variation. We call it Sales Volatility, defined as,

$$Sales\ Volatility = \frac{Standard\ Deviation\ of\ Sales}{Average\ Sales}.$$

Higher values for this measure imply higher risk associated with the company's operating earnings.

Operating leverage is the second component that amplifies the sensitivity of a firm's operating earnings. It refers to the employment of fixed costs in production operations. Higher fixed costs imply higher operating leverage which exacerbates fluctuations of operating earnings over the business cycle. Unfortunately, it is not easy to compile data on fixed and variable costs of production. Therefore, we have to derive substitutes for this ratio. The ratio of net fixed assets per employee (NFAPEREM) is used as a surrogate for operating leverage.

$$Net\ Fixed\ Assets\ per\ Employee = \frac{Net\ Fixed\ Assets}{Employee}.$$

Net fixed assets per employee is also known as a measure of capital intensiveness. Higher values for this ratio imply higher fixed production costs and, as a result, higher business risk.

E. Size. Intuitively, one expects that large firms will be less risky than smaller ones. In other words, risk and the size of the firm should be inversely associated. There are a few accounting variables which have been suggested as a proxy for the size of a firm, e.g., total assets, common equity, sales, and total earnings. In our analysis, we use the natural log transformation of sales as a proxy of size. In the empirical analysis, it is referred to as Revenue.

$$REVENUE = \ln\ (Sales)$$

F. Cash Flow Risk Measures. Although primitive forms of cash flow statements date back to the second half of the 19th century, they were not required in corporate financial statements until 1988. Use of cash flow ratios in financial statement analysis as a measure of risk was boosted when Beaver (1966) found that one of the best single ratios for predicting bankruptcy was the cash flow to long term debt. More recently Ismail and Kim (1989) found that traditional accounting risk measures based on the cash flow yield additional explanatory power over that contributed by the earnings risk measures in explaining the cross sectional variability in market betas.

The cash flow ratios considered in our study are calculated using the following definition of cash-flow-from-operations suggested by Gombola and Ketz (1983); "Cash flow from operations (CFO) is estimated by adjusting working capital from operations for changes in the current assets and current debt except for cash."[20]

$$\mathbf{CFO=(EBITA+DEPR+DEFTAX)_t\ -(CA-CL-CASHSTI)_t\ -(CA-CL-CASHSTI)_{t-1}}$$

where,

EBITA = Earnings before interest and taxes,
DEPR = Depreciation,
DEFTAX = Deferred taxes,
CA = Current Assets,
CL = Current Liabilities, and
CASHSTI = Cash and short term investment.

The cash-flow-based traditional accounting risk measures used in this study are the following four:

Cash flow to total assets (CFOTA),

$$\textit{Cash Flow to Total Assets} = \frac{\textit{Cash Flow from Operations}}{\textit{Total Assets}},$$

cash flow to common equity (CFOE),

$$\textit{Cash Flow to Equity} = \frac{\textit{Cash Flow from Operations}}{\textit{Equity}},$$

cash flow profit margin (CFOMRG),

$$\textit{Cash Flow Profit Margin} = \frac{\textit{Cash Flow from Operations}}{\textit{Sales}},$$

and cash flow to debt (CFOD),

[20] Gombola and Ketz, (1983), pp. 107-8.

$$Cash\ Flow\ to\ Debt = \frac{Cash\ Flow\ from\ Operations}{Debt}.$$

Cash flow to total assets (CFOTA), cash flow to equity (CFOE), and cash flow profit margin (CFOMRG) are measures of a firm's efficiency and profitability. As such, they bear a negative association with risk. Cash flow to debt (CFOD), on the other hand, indicates a firm's ability to cover its liabilities with its annual cash flow. The higher this ratio, the better is the firm's ability to cover its fixed obligation; hence, an inverse association with risk is implied.[21]

F. Market Value Ratios. All the previous categories brought together ratios that describe a specific aspect of the entity, i.e., liquidity, profitability and so on. Market value ratios give a more general and broad picture of the firm's activities.

Price Earning ratio (PEREXCL) expresses the relationship between the market price of a share of the common stock and that stock's current earnings per share.[22]

$$Price\ Earning\ Ratio\ or\ (P/E) = \frac{Market\ Price\ per\ Share}{Earnings\ per\ Share}.$$

Investors view P/E ratios as measures of a firm's future earning power. The general rule implies that high growth companies will have a high P/E ratio and vice versa.

[21]The incorporation of cash flow based risk measures in our data set works as another constraint that narrows the sample size. The original sample size of 373 companies was reduced to 276.

[22]P/E ratios do not have any meaning when the firm has abnormally low profits in relation to the asset base, or when the firm has losses. The P/E ratio in these cases would be abnormally high or negative. Gibson (1989),p. 350

If we use P/E as a proxy for an entity's growth rate, then based on the analysis of Beaver *et al.* (1970),[23] we can argue that a positive association exists between the P/E ratio and risk. The argument is that the earnings stream of an expanding company will be more volatile than the earnings stream of a low-growth company.

Another ratio to be considered is the Dividend Payout (DPOUT),

$$\textit{Dividend Payout} = \frac{\textit{Dividends per Share}}{\textit{Earnings per Share}}.$$

A growing company is a company faced with one or more investment projects having a positive net present value. The cheapest source to finance these projects is retained earnings. Therefore, it is logical to expect that the dividend payment of these companies will be minimal. On the other hand, a company that has exhausted its possibilities for growth will distribute the lion's share of its earnings to shareholders. It follows that a company's potential for growth and dividend payout are inversely related. Employing the previously reviewed argument on growth and risk, we expect a negative association between dividend payout and risk.[24]

Market to Book Value (MRKTOBKV) is the ratio of the market value of a stock to its historical cost.

$$\textit{Market to Book Value} = \frac{\textit{Market Price per share}}{\textit{Book Value per Share}}$$

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[23]Beaver et al. (1970), p.661.

[24]Beaver et al. (1970) argue that dividend payout ratio can be seen as a, "surrogate for management's perception of the uncertainty associated with the firm's earnings."

Historical cost or book value measures previous asset expenditures, while market value may represent a surrogate of a firm's future potential as seen through the eyes of investors. Market to Book Value is a proxy for the market (monopolistic) power of the firm. Higher values for this ratio may indicate greater market power for the entity - implying a lower level of associated risk.[25]

The titles of financial accounting variables, their COMPUSTAT "Data Item Number", as well as their quasi acronyms under which appear in this empirical analysis, are presented in table 3.2. Table 3.3 contains all the derived series while table 3.4 introduces all the traditional accounting risk measures (TARMs) used in the empirical analysis. Finally, table 3.5 presents the descriptive statistics for the TARMs.

3.B. Limitations of Accounting Risk Measures.

There are several limitations inherent in the use of accounting variables and ratios. These limitations are associated with established accounting practices, or deliberate misuse of the accounting procedures.

The first of these limitations is credited to the use of the historical cost principle. Although the fifth Statement of Financial Accounting Concepts identifies five different measurement attributes, historical cost is the one used the most in

[25]Thomadakis (1976), Hite (1977), Subrahmanyam-Thomadakis (1980), and Chen, et al. (1986), show that there is an inverse relation between market power and systematic risk.

TABLE 3.2

Financial Accounting Variables Extracted from COMPUSTAT

Variable	**Symbol**	**Compustat #**
CASH + SHORT TERM INVESTMENT	CASHSTI (1983-1978)	1
ACCOUNTS RECEIVABLE - TOTAL	AR83 (AR82)	2
INVENTORIES - TOTAL	INV83 (INV82)	3
ASSETS CURRENT - TOTAL	CA (1983-1978)	4
LIABILITIES CURRENT - TOTAL	CL (1983-1978)	5
ASSETS - TOTAL	TA	6
FIXED ASSETS NET - TOTAL	NFIXAS	8
DEBT (TOTAL LONG TERM)	D83	9
SALES (NET)	SALES (1983-1979)	12
OPERATING INCOME BEFORE DEPRECIATION	OEBFRD	13
DEPRECIATION AND AMORTIZATION	DEPRC (1983-1979)	14
INTEREST EXPENSE	INTEREXP	15
DIVIDENDS - PREFERRED	DIVPREF	19
	IBEXA	
DIVIDENDS - COMMON	DIVCOM	21
PRICE - CLOSE	PRCL83	24
EMPLOYEES	EMPL	29
DEFERRED TAXES AND INVESTMENT TAX CREDIT	DEFTAX (1983-1979)	35
COST OF GOODS SOLD	CGS	41
COMMON SHARES USED TO CALCULATE EARNINGS PER SHARE (PRIMARY)	CSRS	54
EARNINGS PER SHARE (PRIMARY)	EPSEXCL	58
EQUITY COMMON - TOTAL	E83 (E82)	60
ACCOUNTS PAYABLE	ACPAY	70
	ACREXP	
PRETAX INCOME	EBTAX	170
INCOME (LOSS) NET	NI (1983-1979)	172
WORKING CAPITAL	WCAP83 (WCAP82)	179
LIABILITIES - TOTAL	TL	181

TABLE 3.3

**Derived Series
Used to Create
Traditional Accounting Risk Measures**

Derived Series	Symbol	Formula
ASSETS QUICK	QA	CASHSTI+AR83;
EXPENSES BEFORE TAX	EXPBTAX	SALES83-EBTAX;
GROSS PROFIT	GRSPROF	SALES83-CGS;
EARNINGS BEFORE INTEREST & TAXES	EBIT	OEBFRD-DEPRC83;
PURCHASES	PURCH	CGS+INV83-INV82;
VALUE PER SHARE (BOOK)	BOOKVSR	E83/CSRS;
AVERAGE ACCOUNTS RECEIVABLE	AVAR	.5*(AR82+AR83);
AVERAGE INVENTORY	AVINV	.5*(INV83+INV82);
AVERAGE ANNUAL SALES	AASALES	SALES83/365;
AVERAGE ANNUAL COST OF GOODS SOLD	AACGS	CGS/365;
AVERAGE ANNUAL PURCHASES	AAPURCH	PURCH/365;
AVERAGE SALES	AVSALES	
= (Sales83+Sales82+Sales81+Sales80+Sales79)/5		
ST. DEVIATION OF SALES	SDSALES	
= {.25[(Sales83 - AVSales)2+...+(Sales79-AVSales)2]}1/2		
AVERAGE EQUITY	AVE	.5*(E83+E82);
AVERAGE WORKING CAPITAL	AVWCAP	.5*(WCAP83+WCAP82)
CASH FLOW FROM OPERATIONS	CFOXX	
=(EBITA+DEPRC+DEFTAX)t -(CA-CL-CSHSTI)t+(CA-CL-CSHSTI)t-1		
DIVIDENDS PER COMMON SHARE	DIVPERCS	DIVCOM/CSRS;

TABLE 3.4

Definitions
of Traditional Accounting Risk Measures (TARMs)

	TARMs	SYMBOL	FORMULA
	Liquidity Ratios		
1	CURRENT RATIO	CR	CA/CL
2	QUICK RATIO	QR	QA/CL
3	WORKING CAPITAL TURNOVER	WCTOV	SALES/AVWCAP
4	AVERAGE COLLECTION PERIOD	COLPERD	AVAR/AASALES
5	INVENTORY TURNOVER	INVTOV	CGS/AVINV
6	DAYS RESOURCES TIED UP IN WCAP	DRTINWC	
	INV83/AACGS)+(AR83/AASALES)-(ACPAY/AAPURCH);		
7	INVENTORY TO CURRENT ASSETS	INVTOCA	INV/CA
8	INVENTORY TO WORKING CAPITAL	INVTOWC	INV/WCAP
	Leverage Ratios		
1	TOTAL LIABILITIES TO TOTAL ASSETS	TLTOTA	TL/TA
2	TOTAL LIABILITIES TO TOTAL EQUITY	TLTOE	TL/E
3	DEBT TO NET FIXED ASSETS	DTONFIXAS	D/NFIXAS
4	COVERAGE RATIO	COVERAGE	EBTAX/INTEREXP
	Profitability/Efficiency Ratios		
1	GROSS PROFIT MARGIN	GRSMRG	GRSPROF/SALES
2	RETURN ON TOTAL ASSETS	REOTA	NI/TA
3	RETURN ON COMMON EQUITY	REOE	(NI-DIVP)AVE
4	TOTAL ASSETS TURNOVER	TATOV	SAFES/TA
5	NET FIXED ASSETS TURNOVER	NFXASTOV	SALES/NFIXAS
6	EXPENSES(BEFORE TAX) TO REVENUE	EXPTOREV	EXPBTAX/SALES
	Business Risk		
1	VOLATILITY OF SALES	VSALES	SDSALES/AVSALES
2	VOLATILITY OF EARNINGS	VEBIT	SDEBIT/AVSALES
3	NET FIXED ASSETS PER EMPLOYEE	NFAPEREM	NFIXAS/EMPL
	Size		
1	REVENUE	REVENUE	ln(SALES)

TABLE 3.4 Cont'd

Definitions
of Traditional Accounting Risk Measures (TARMs)

	TARMs	SYMBOL	FORMULA
	Cash Flow from Operations Ratios		
1	CASH FLOW TO TOTAL ASSETS	CFOTA	CFO/TA
2	CASH FLOW TO DEBT	CFOD	CFO/D
3	CASH FLOW TO EQUITY	CFOFORCS	CFO/E
4	CASH FLOW PROFIT MARGIN	CFOMRG	CFO/SALES
	Investors		
1	PRICE EARNING RATIO	PEREXCL	PRCL/EPS
	EXCLUDING EXTRAORDINARY ITEMS		
2	DIVIDEND PAYOUT	DPOUT	DIVPERCS/EPS
3	MARKET TO BOOK VALUE	MRKTOBKV	PRENDY/BOOKVS

TABLE 3.5

Simple Statistics
for Traditional Accounting Risk Measures
373 Companies from the 1983-1986 period

TARMs	N	Mean	Std. Dev.	Min.	Max
CR	373	2.544	1.144	1.008	10.073
QR	373	1.449	0.799	0.347	7.367
WCTOV	373	7.507	13.321	0.64	140
COLPERD	373	56.429	20.22	13.006	136.319
INVTOV	373	5.698	7.847	0.997	114.489
DRTINWC	373	91.688	65.986	-36.042	372.181
INVTOCA	373	0.393	0.127	0.023	0.807
INVTOWC	373	0.969	1.924	0.033	30.364
TLTOTA	373	0.453	0.124	0.154	0.821
TLTOE	373	0.959	0.604	0.182	4.589
DTONFXAS	373	0.51	0.594	0.02	8.297
COVERAGE	373	11.353	20.771	0.178	270.38
GRSMRG	373	0.341	0.136	0.057	0.763
REOTA	373	0.071	0.037	0	0.211
REOE	373	0.138	0.068	0.001	0.428
TATOV	373	1.375	0.437	0.419	3.551
NFXASTOV	373	5.079	3.263	0.683	21.19
EXPTOREV	373	0.906	0.058	0.64	0.999
VEBIT	373	0.03	0.02	0.004	0.144
VSALES	373	0.158	0.105	0.016	0.914
NFAPEREM	373	32.758	51.271	2.087	460.417
REVENUE	373	6.307	1.823	2.424	11.391
PEREXCL	373	22.752	80.135	4.335	1295
DPOUT	373	0.468	1.881	0	36.017
MRKTOBKV	373	1.843	1.05	0.498	10.055
CASH	373	0.166	0.265	0.001	3.185
PM	373	0.056	0.034	0.001	0.207

practice. Historical cost refers to the recording and reporting of asset values as their dollar acquisition costs. Historical valuation and recording owes its popularity to the fact that it is the least ambiguous to use.

The simplicity of historical valuation is also its weakness. The problem becomes obvious when the assets and liabilities valued are long lived. In this case, the difference between the originally recorded historical value and the current replacement value may be substantial. Financial information extracted from a statement using historical valuation may be of little value in aiding investment or management decision making.

Another limitation of the accounting variables has to do with differences in accounting practices. This problem may limit, or make less meaningful, any comparisons between companies; for example, the different methods used in valuing inventories and the rather subjective procedures used to identify the useful life of assets.

Furthermore, changes in accounting principles may make the comparisons of present and past financial information for the same company meaningless. For example, if a company decides to switch from one inventory principle to another, profitability analysis becomes rather complicated. The analysis becomes complicated because, for the year of change, inventory is in LIFO, while all previous years are based on FIFO, and vice versa. The use of LIFO to account for the inventory of a company may limit the usefulness of the inventory turnover ratio for investment analysis. While inventory stock is valued at prices determined in the past, the cost-of -goods-sold is valued in current prices.

Deliberate action taken by the management of a company to alter certain ratios makes them unreliable. This practice, known as *window dressing*, is well documented in accounting literature.[26] A simple example of window dressing works in the following way. Right before the end of the fiscal year management would pay off some of its current liabilities and then borrow again at the beginning of the new year. This action creates the illusion of a higher current and quick ratio.

Another problem encountered when using financial ratios is reflected in their proper interpretation. For example, it is known that higher values for current and quick ratios are desirable because it is assumed that the firm is more liquid. But high liquidity ratios may also imply the management's inability to use its capital profitably. A second example on the proper interpretation of ratios comes from the group of leverage ratios, where it is implied that the lower the leverage ratio the better off the company. But this simplistic statement ignores such aspects as the role of debt on the company's weighted cost of capital and the preferential tax treatment of debt.

It should not escape our attention that all the information about the company provided from the analysis of financial statements is static. It is accurate and captures the firm's characteristics at the very moment of its compilation. As a result, this

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[26] According to Gallant (1993), in 1992 Leslie Fay Cos., a retailer, reported earnings of $23.9 million. Latter it was discovered that inventory figures had been manipulated to conceal an actual loss of $13.7 million. The author says that such frauds as Leslie Fay, are a bit unusual, but what does seem to occur often is what Wall Street refers to as "window dressing". This implies the use of legal accounting tricks that beautify financial statements.

See also "Cute Tricks on the Bottom Line" in Fortune, April 14, 1989.

information may not be representative of the firm's characteristics before or after the financial statement was completed. Seasonality of operations or certain unexpected events may be the cause of such discrepancies. For example, several companies experience a seasonal pattern in their operations, as a result some balance sheet and income statement entries will fluctuate with the time of the year the statements are prepared. Major events such as a casualty loss or sale of a major asset, may dramatically affect the company's structure.

Many important variables are not shown in the financial statement. For example it is difficult to quantify such aspects as the quality of management and employees in general.

Finally it should be noted that there is the following difference between traditional accounting risk measures and market measures of risk. The market risk measures reflect the systematic component of risk, while TARMs account for total risk.

According to modern portfolio theory; total risk, or the risk associated with the variability of an asset's returns, can be divided into two components - systematic and non-systematic. The former is the component of risk that can not be eliminated with diversification. Investors are rewarded for bearing this risk with higher returns. Diversification eliminates the non-systematic component of risk, and the market does not offer a premium for bearing this type of risk. Traditional accounting risk measures, however, are surrogate measures for total risk. They reflect actions and decisions affecting the company's earnings.[27]

4. APT Risk Measures, the Dependent Variables

APT does not specify the nature or the number of common risk factors entering the asset return generating model. This weakness in APT means that we must not only estimate the APT risk measures, but we must also decide how many to retain for empirical analysis.

We used a principal factor analysis of stock returns to estimate the risk measures.[28] The scree plot was used in order to decide how many should be retained, Graph 1 shows the plot of the eigenvalues. The slope of the scree plot becomes flat approximately after the fifth eigenvalue. This indicates that five factors may be sufficient in representing the asset return generating model. Our decision to accept five factors was partially supported by the empirical studies of APT.

As discussed in chapter II, some of these studies using factor analysis suggested that the number of factors increases with the sample size, while others claimed that factors of higher order may be trivial. On the other hand, studies using pre-specified factors in the asset return generating process indicate that variables such as term structure, default risk premia, industrial production, sales and inflation seem

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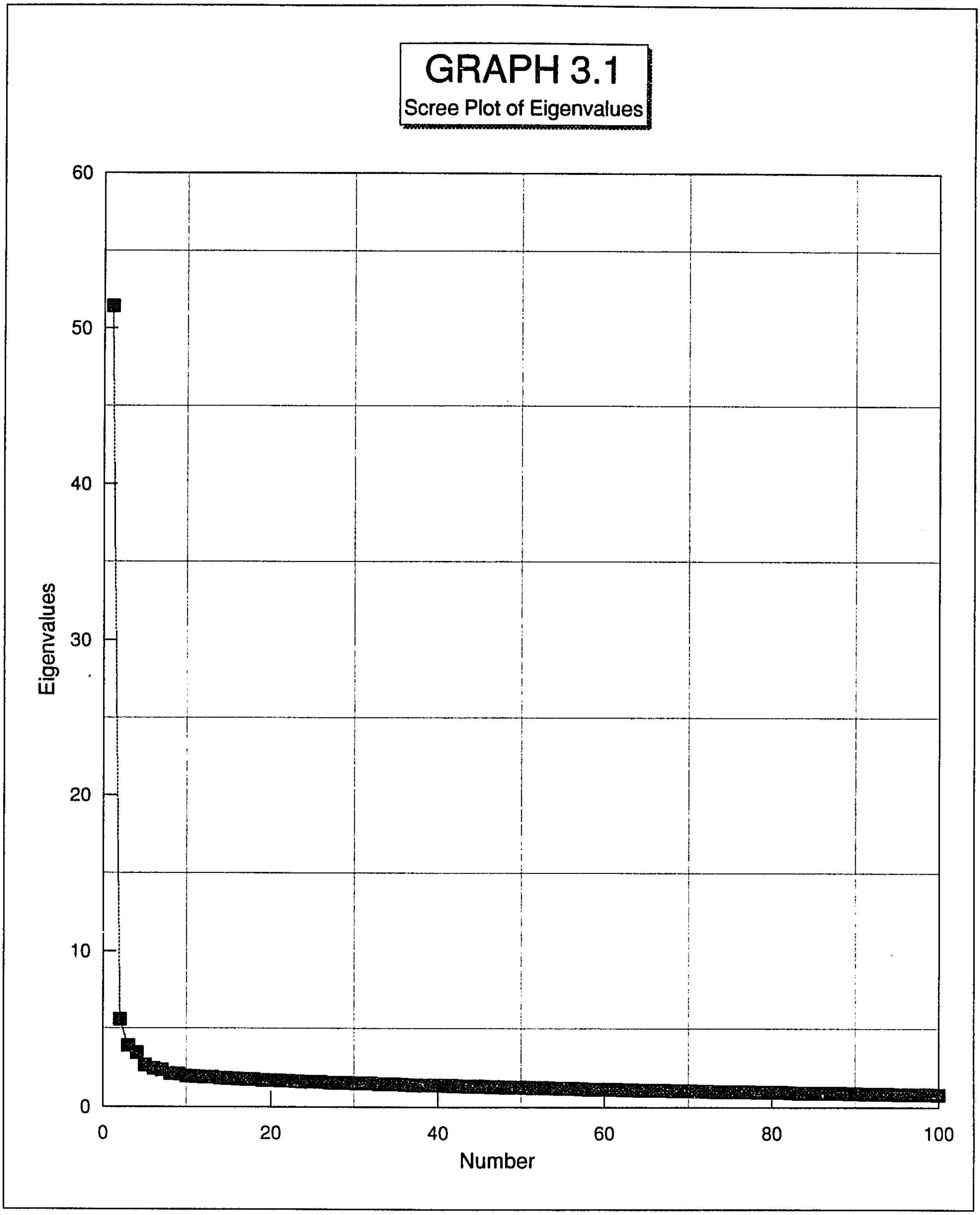
[27]For more details, see Beaver *et al.* (1970), pp. 659-60, Bildersee (1975), p. 82.

[28]The computation of prior communality estimates was performed by using the option "PRIORS=SMC" in SAS. This option sets the prior communality estimates for each variable to its squared multiple correlation with all other variables. See SAS User's Guide: Statistics, Version 5 Edition, pp. 342-343.


GRAPH 3.1
Scree Plot of Eigenvalues
60
50
40
30
20
10
0
Eigenvalues
0
20
40
60
80
100
Number

to qualify as pervasive risk factors. All of the latter studies agreed with the postulate that five risk factors would adequately describe the risk return process.

Our analysis combines the two approaches. We start by using factor analysis to extract estimates of APT risk sensitivities. The results of the empirical studies using pre-specified factors lead us towards retaining five of the extracted factors. However, this conclusion is not finalized until we find support by the scree plot.

Table 3.6 summarizes the simple statistics for the estimated APT risk sensitivities across the set of 373 companies. As mentioned at the beginning of this chapter, estimated betas vary across companies and the model used in this study should explain this variation. We provide a picture of the cross sectional variation in table3.7. This table contains the means of the estimated betas of companies grouped according to the two digit SIC codes. Obviously, the APT risk measures vary widely among the different groups of companies. For the first APT risk measure, the maximum value, which corresponds to the Printing and Publishing industry (SIC=27), is almost twice as large as the minimum beta which corresponds to Textile and Mill products (SIC=22). For the rest of the estimated APT risk measures, these differences are even larger. Variations shown in Table 3.7.

5. Final Comments for the Data Set and the Model in Matrix Form

Naturally, relying on the availability of data in the COMPUSTAT and CRSP files for the creation of the data set introduces sample bias. Usually large companies

TABLE 3.6

Simple Statistics
for Estimated APT Risk Measures
373 Companies from the 1983-1986 period

Variable	N	Mean	Std. Dev.	Min.	Max.
b_1	373	0.346	0.135	0.037	0.706
b_2	373	0.028	0.119	-0.319	0.283
b_3	373	0.002	0.103	-0.354	0.286
b_4	373	0.011	0.096	-0.167	0.621
b_5	373	0.003	0.085	-0.691	0.162

TABLE 3.7

Cross Sectional Variation
of Estimated APT Risk Measures
373 companies from the 1983-1986 period

SIC Code	b_1	b_2	b_3	b_4	b_5
20	0.36	-0.02	0.11	-0.03	-0.01
21	0.34	-0.01	0.10	-0.03	0.02
22	0.24	0.06	0.04	0.01	0.03
23	0.28	·0.08	0.03	-0.01	0.01
24	0.41	-0.02	0.00	-0.05	-0.06
25	0.31	0.09	0.03	-0.01	-0.03
26	0.42	-0.01	0.04	-0.06	-0.02
27	0.43	0.01	0.06	-0.03	-0.01
28	0.40	-0.01	0.03	-0.02	0.01
29	0.31	-0.01	0.06	0.18	0.01
30	0.34	0.14	-0.01	0.01	-0.01
31	0.27	0.10	0.05	0.01	0.02
32	0.25	0.08	-0.02	0.03	0.04
33	0.34	0.06	-0.04	0.00	-0.01
34	0.28	0.10	0.01	0.01	-0.01
35	0.35	0.07	0.00	0.00	-0.01
36	0.36	0.02	-0.06	0.02	-0.02
37	0.34	0.03	-0.07	0.01	0.01
38	0.35	0.03	-0.06	0.03	0.03
39	0.30	-0.01	0.00	0.02	0.01
MIN	0.24	-0.02	-0.07	-0.06	-0.06
MAX	0.43	0.14	0.10	0.18	0.04

Short titles for each one of the industries corresponding to the SICs are given in table 3.1.

tend to have data in both COMPUSTAT and CRSP tapes.[29] This type of non-randomness bias has been an inherent problem in all previous studies that use simultaneously financial accounting data and stock returns. All studies examining the association between market risk and accounting risk measures rely on samples created within the confines of COMPUSTAT and CRSP data availability.

Finally, we summarize this model in a matrix notation customized for the needs of this study.

$$\tilde{R}_{it} = E(\tilde{R}_{it}) + \beta_{ij}(\tilde{F})_{jt} + \tilde{\epsilon}_{it}; \qquad (3.5)$$

where,

$\tilde{R}_{it}$ is the matrix of stock returns with, $i = 1,\ldots N$, representing the number of securities used in the sample. In this study N is equal to 373 and t stands for the trading days for which we have extracted stock returns. In this study t starts the first trading day of 1984 and ends on the last trading day of 1986.

$E(\tilde{R}_{it})$ is the matrix of expected returns;

β_{ij} is the matrix of estimated APT risk measures with $j = 1,\ldots,k$ being the number of pervasive risk factors - based on the scree plot, k is equal to five in this study;

$(\tilde{F})$ is the matrix of pervasive risk factors, and

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[29] Eskew (1989) notes that "COMPUSTAT and CRSP file limitations do produce samples with certain biases. The firms tend to be larger than average and are less risky than average." (p. 113).

$\tilde{\epsilon}$ is the matrix of error terms.

In regard to the risk factors $(\tilde{F})$, we assume that they are expressed in deviation from their expected values, therefore $E(\tilde{F})=0$. We further assume that they are not correlated with the firm specific component of stock returns ($\tilde{\epsilon}$). The risk factors themselves may be correlated or not. Regarding the firm specific components, we assume that they are not correlated with one another. These assumptions facilitate the use of principal factor analysis for the estimation of the betas. The principal factor analysis with constraints leads to unique betas.

The matrix notation of the model used in order to examine the association between betas and TARMs is as follows:

$$(\beta_{ij})' = (\gamma_{jp})\ (TARM_{pi}), \tag{3.6}$$

where,

$(\beta_{ij})'$ is the transpose of the above mentioned matrix of the estimated betas;

γ_{jp} is the matrix of estimated regression coefficients determining the response of the estimated betas to changes in the accounting risk measures, p is the number of accounting risk measures extracted from the financial statement corresponding to the year prior to the one for which we have extracted stock returns. In our case they correspond to fiscal year 1983; and,

$TARM_{pi}$ is the matrix of the accounting risk measures found to be influential in explaining the fluctuations of the estimated APT risk measures.

In the following chapter we proceed with the empirical testing of the hypothesized relationship given by equation 3.6. The empirical testing is based on a step-wise regression procedure, determining the simplest possible model for the hypothesized relationship.

CHAPTER IV

EMPIRICAL ANALYSIS RESULTS

Based on the Sample Covering the 1983-1986 Period

In this chapter we empirically test whether traditional accounting risk measures (TARMs) can be used to explain the cross sectional variation of the Arbitrage Pricing Theory (APT) risk measures through correlation and regression analysis of a sample of manufacturing companies. The results of the study are encouraging and lend support to the findings of McGowan, Etebari and Horrigan (MEH) (1991).

This chapter consists of six parts. Part one reports correlation analysis of estimated betas in relation to extracted accounting risk measures. Part two presents the results of regression analysis based on the sample of 373 industrial companies. This section examines five regression models, one for every beta, in which the explanatory variables in each specification were chosen through a stepwise regression procedure.[1]

Part three, presents an analysis of residuals. In the studies examining the relation between accounting risk measures and market risk, the use of accounting variables as explanatory variables may introduce severe multicollinearity and, also, the residuals in the regression model tend to be correlated. In the stepwise regression

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[1]The stepwise procedure can be seen as a surrogate for the principal components regression.

procedure (part two), we discuss the multicollinearity problem in the suggested models.

Part four contains the regression analysis results at the portfolio level. Recent studies reveal that cash-flow-based risk measures add to the explanatory power of models explaining the cross-sectioned variation of market beta. McGowan, Etebari, and Horrigan conclude that future research should incorporate "more data from the funds flow statements." Motivated by this conclusion, part five contains the regression analysis results for a new sample of companies created after the incorporation of cash flow based risk measures in the analysis. Finally, we close this chapter with a comparative analysis of the regression results for each APT risk measure across different sample specifications.

1. Predictive Correlation Analysis of Individual Stocks

We start the empirical implementation of this study using univariate analysis. More specifically, we use predictive correlation analysis in order to establish the ability of individual accounting variables to explain the cross-sectional variation of estimated APT risk sensitivities, (b's). Table 4.1 reports the correlation coefficients for 1983 financial accounting data and betas estimated from daily stock returns covering the 1984-1986 period. This approach referred to as predictive correlation

TABLE 4.1

Correlation Matrix
Among Estimated Arbitrage Pricing Theory Risk Measures
and Traditional Accounting Risk Measures

373 Companies from the 1983-1986 period

	b_1	b_2	b_3	b_4	b_5
CR	-0.259	0.316	-0.064	-0.003	0.132
QR	-0.18	0.266	-0.084	0.019	0.131
WCTOV	0.014	-0.177	0.174	0.281	0.002
COLPERD	-0.065	0.161	-0.317	-0.032	0.066
INVTOV	-0.026	-0.012	0.123	0.129	-0.008
DRTINWC	-0.162	0.204	-0.243	-0.021	0.103
INVTOCA	-0.119	0.074	0.045	-0.06	-0.023
INVTOWC	-0.001	-0.125	0.098	0.23	0
TLTOTA	-0.04	-0.08	0.048	0.025	-0.096
TLTOE	-0.141	-0.01	0.009	0.013	-0.089
DTONFXAS	-0.243	0.186	0.006	-0.007	0.076
COVERAGE	0.057	0.017	0.02	-0.051	0.024
GRSMRG	0.2	-0.105	-0.133	-0.149	0.046
REOTA	0.168	-0.047	0.008	-0.053	0.068
REOE	0.134	-0.069	-0.044	-0.029	0.048
TATOV	-0.211	0.151	0.171	0.025	0.003
NFXASTOV	-0.36	0.274	-0.041	0.019	0.043
EXPTOREV	-0.203	0.074	0.039	-0.003	-0.036
VSALES	-0.122	0.035	-0.231	0.073	0.033
VEBIT	-0.026	0.017	-0.275	-0.005	0.052
NFAPEREM	0.048	-0.311	0.218	0.602	-0.004
REVENUE	0.674	-0.668	0.16	0.059	-0.219
PEREXCL	-0.056	0.009	-0.01	-0.055	-0.062
DPOUT	0.007	-0.033	0.073	-0.033	-0.049
MRKTOBKV	0.177	-0.043	-0.288	-0.091	0.021
CASH	0.009	0.028	-0.136	0.004	0.076
PM	0.206	-0.084	-0.097	-0.051	0.094

analysis because it correlates financial accounting measures from this period with estimated betas from a future period.

A first, quick look at the correlations reported in table 4.1 reveals the existence of linear associations between the APT risk measures (b's), and several of the accounting variables. In the rest of this section we discuss the set of accounting variables bearing a linear correlation with the corresponding APT risk measures at a 5% level of significance. An impressive number of accounting variables satisfies this criterion across APT risk measures.

Close to two-thirds of the accounting variables bear a statistically significant association with the first APT risk measure. A measure of size (REVENUE) carries the highest correlation with the first of the estimated betas. The correlation coefficient between the first APT risk measure and sales is 0.674 which means that two-thirds of the variability of the first beta is explained using a linear model that relies solely on revenues from sales.

Another interesting fact that we see from table 4.1 is that all of the accounting risk measures from the group 'profitability and efficiency,' are significantly correlated with the first APT risk measure. More careful examination of the signs of these correlations reveals that all of the profitability measures - net profit margin (PM), gross profit margin (GRSMRG), return on total assets (REOTA), and return on equity (REOE) - are positively associated with the first beta. On the other hand, all of the efficiency reflecting accounting risk measures - total assets turnover (TATOV), net fixed assets turnover (NFXASTOV), and expenses to revenue (EXPTOREV) - bear a negative correlation with the first APT risk measure.

Half of the leverage ratios - total liabilities to equity (TLTOE), and debt to net fixed assets (DTONFXAS) - are significantly negatively correlated with the first APT risk measure. An inverse linear association is detected with several of the liquidity ratios too. Current ratio (CR), Quick ratio (QR), days resources tied in working capital (DRTINWC), and inventory to current assets (INVTOCA) are the liquidity ratios associated with the first APT risk measure. Finally, a surrogate measure for market power - market to book value (MRKTOBKV) - is positively associated with the first beta, while a measure of business risk - variability of sales (VSALES) - bears a negative correlation.

Almost half of the traditional accounting risk measures that we examine bear a statistically significant association with the second APT risk measure. As we observed with the first beta, sales (REVENUE) bears the strongest correlation with the second beta too. Examination of the correlations of the liquidity ratios reveals that with the exception of three ratios - cash (CASH), inventory turn over (INVTOV) and inventory to current assets (INVTOCA) - all the rest of them are significantly correlated with the second beta.

Debt to net fixed assets (DTONFXAS) is the only leverage ratio showing a significant correlation with the second beta. The number of profitability and efficiency ratios which are associated with the second APT risk measure is also smaller, compared to the first. Namely, we have three ratios from the profitability/efficiency group - gross profit margin (GRSMRG), total assets turnover (TATOV), and net fixed assets turnover (NFXASTOV) - significantly correlated with the second beta. Finally, there is one measure of business risk - net fixed assets per employee (NFAPEREM) - which bears a significant linear correlation with the second beta.

Comparison of the signs of accounting variables bearing a significant correlation with the first and second APT risk measures, reveals that the two seem to complement each other. The following accounting variables - CR, QR, DRTINWC, DTONFXAS, GRSMRG, TATOV, NFXASTOV, REVENUE - are significantly correlated with the first and second beta. Comparison of their correlations reveals that they alternate is sign between the first and second APT risk measures. This may be a sign of their nature as complements in the type of risk that the first couple of APT risk measures capture and reflect.

Unlike the previous two betas where we observed the strongest correlation with the measure of size (REVENUE), the strongest association with the third beta comes from a liquidity variable, the collection period (COLPERD). Other liquidity risk measures significantly associated with the third beta are the working capital turnover (WCTOV), inventory turnover (INVTOV), days resources tied in working capital (DRTINWC), and cash (CASH).

Although none of the leverage ratios bears a significant correlation with the third beta, both measures of business risk - variability of sales (VSALES), and net fixed assets per employee (NFAPEREM) - do reveal a significant linear association.

We also observe that two of the profitability/efficiency risk measures - gross profit margin (GRSMRG), and total assets turnover (TATOV) - are significantly associated with the third APT risk measure.

Sales (REVENUE), although significantly correlated with the third APT risk measure, reveals a relatively weaker association when compared with the corresponding associations to the first and second betas. The measure of market power - market to book value (MRKTOBKV) - is bearing a strong linear association with the third APT measure of risk.

Overall, examination of the accounting risk measures associated with the third APT risk measure reveals that it may be capturing a different aspect of risk than the first and second betas. This argument is based on the following observations: first, the strongest linear correlation among the set of accounting variables and the third beta occurs with a measure of liquidity not a measure of size as it was for the previous two. Also, none of the accounting risk measures from the leverage group is significantly correlated with the third APT risk measure.

Based on the nature of the set of accounting risk measures which are significantly correlated with the fourth APT risk measure we can argue that it may represent still another aspect of risk. Unlike all previous measures of systematic risk, the fourth beta is not significantly correlated with sales (REVENUE). The accounting variable that bears the strongest linear correlation with the fourth APT risk measure is the surrogate measure for the degree of operating leverage - net fixed assets per employee (NFAPEREM). A simple linear regression model using the NFAPEREM as an explanatory variable accounts for 36 per cent of the variation of the fourth APT risk measure. Other variables bearing a significant association are the working capital turnover (WCTOV), inventory turnover (INVTOV) as well as inventory to working capital (INVTOWC) from the liquidity group, and gross profit margin (GRSMRG) from the profitability group.

Fewer accounting risk measures bear a significant linear correlation with the fifth APT risk measure than with any of the former. There are only three variables with significant correlations: sales (REVENUE), and two liquidity measures - current ratio (CR) and quick ratio (QR). None of the leverage, or profitability and efficiency accounting risk measures is significantly correlated with the fourth beta.

Overall, the results of the correlation analysis provide initial supportive evidence for our hypothesis. The accounting risk measures seem to posses significant power in explaining the cross sectional variations of the APT risk measures. More specifically, the following points have been illustrated:

- A large number of accounting variables are significantly correlated with the first two of the APT risk measures, and that these two betas seem to complement each other. A measure of size - sales (REVENUE) - carries the strongest correlation with each one of them.

- Liquidity related risk measures, and more specifically average collection period (COLPERD) is the accounting variables that could account for most of the cross-sectional variations of the third beta. Operating leverage - net fixed assets per employee (NFAPEREM) - seems to posses the highest explanatory power regarding the fourth beta.

In the following section we move from a univariate to a multiple regression analysis. We attempt to illustrate that traditional accounting risk measures are statistically significant explanatory variables regarding cross-sectional variations in APT risk measures. Various linear regression models are used toward this end.

2. Regression Analysis

The objective of this study is to examine the ability of financial accounting variables in explaining the cross sectional variation of APT risk measures. In the previous section, using correlation analysis,preliminary evidence to support this hypothesis was presented. In this section, we use multiple regression analysis to study the linear association between each one of the estimated APT risk measures and a set of financial accounting variables.

In chapter III, when presenting each one of the accounting variables, we also discussed how each is associated to (or expected to influence) total risk. An attempt to use all of them in equation (3.4), the suggested regression model, however, will introduce severe multicollinearity.[2] According to Johnston (1972) this may cause the following problems: "The precision of estimation falls so that it becomes very difficult, if not impossible, to disentangle the relative influences of the various X

[2]"Multicollinearity is defined as the existence of one or more near exact linear relations among columns of the regressor matrix X." Judge et *al.* (1988), p. 882.

variables."[3] In order to alleviate this problem, we introduce the stepwise selection procedure based on the following criteria/steps.

First, for each one of the estimated betas we find the maximum attainable adjusted coefficient of determination ($\bar{R}^2$). Theoretically, if we keep adding explanatory variables in a regression model the coefficient of determination (R^2) will keep growing towards a maximum of 1.0 or 100 per cent. The $\bar{R}^2$ accounts for the loss of the degrees of freedom that we encounter as explanatory variables are added to regression model. Therefore, every additional explanatory variable will increase the $\bar{R}^2$ only if the explanatory power from the added variable counterweights the decline from the adjustment in the degrees of freedom. In the first step, we try find the maximum value that $\bar{R}^2$ can take for each one of the APT risk measures given our set of explanatory variables. We call this maximum adjusted coefficient of determination ($\bar{R}^2$) the *saturation point*. The results of this analysis are as follows:

The adjusted coefficient of determination ($\bar{R}^2$) begins to decline with the addition of a 14th variable in an attempt to explain the first APT risk measure, the 9th variable in the case of the second APT risk measure, the 14th, 15th and 10th when attempting to explain the third, fourth, and fifth APT risk measures respectively. The associated saturation points for the regression models are 0.66, 0.50, 0.23, 0.50 and 0.06, again respectively.

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[3]Johnston (1972), p. 160.

The above results indicate that models reach a plateau at a level close to their saturation point. For example, examining the potential models for the first of the estimated betas we find that: when using five explanatory variables we have an adjusted R^2 of 0.643, with six it becomes 0.647, with seven it is 0.6497, and the maximum 0.6609 comes with thirteen variables. A similar pattern exists for the rest of the betas.

This finding leads to the second criterion in the stepwise regression procedure. We search for the smallest possible number of explanatory variables in the model that will sustain an $\bar{R}^2$ on a plateau near to its saturation point. Accepting a small loss in explanatory power, we simplify our estimated regression models by dropping variables with little marginal contribution. This procedure decreases dramatically the possibility of severe multicollinearity in the estimated regression models.

Based on this criterion, we keep five variables for the first beta. A small loss in the explanatory power - approximately 2 per cent - is rewarded with a simpler model. The decision to use five instead of thirteen explanatory variables in the estimated regression model reduces the risk of multicollinearity in the model.

For the second beta we can maintain an explanatory power close to the saturation point using three explanatory variables instead of eight. We keep five variables for the third beta; a small sacrifice in explanatory power, allows us to drop eight variables from the regression model. When it comes to the fourth APT risk measure, this criterion simplifies the estimated regression model substantially. The model for the fourth beta uses six instead of fourteen variables. The trade off is a decline of approximately 2 per cent in the $\bar{R}^2$. Finally, accepting an approximate half-a-percentage-point reduction in the $\bar{R}^2$ leads to a simplification of the estimated regression model of the fifth beta. We use three instead of nine explanatory variables. These results are summarized in table 4.2.

The final criterion in the stepwise regression procedure justifies the choice of the specific explanatory variables in each model, based on a low degree of multicollinearity. Although there are several procedures used to measure the degree of multicollinearity, none of them provides specific cutoff points or critical regions that can be used as indicators of when multicollinearity becomes a significant problem.[4] Researchers rely mostly on intuition, or arbitrary rules of thumb. For our analysis, we are using a simple and intuitive measure. We use the Variance Inflation Factor (VIF) in order to examine the degree of collinearity among the *m* independent variables (TARMs). The VIF for the p^{th} independent variable is given by the formula

$$VIF = \frac{1}{(1-R^2)} \tag{4.1}$$

Where the R^2 is the coefficient of determination in the regression model with the p^{th} accounting risk measure as the dependent variable and the remaining *p-1* as the

[4]See Judge et *al.* (1988), chapter 21 for a detailed analysis on multicollinearity.

TABLE 4.2

Number of Independent Variables
and Corresponding Coefficients of Determination
After the First and Second Criterion

	First Criterion		Second Criterion	
	Independent Variables	Adjusted R^2	Independent Variables	Adjusted R^2
b_1	13	.6600	5	.6430
b_2	8	.5000	3	.4930
b_3	13	.2300	5	.2012
b_4	14	.4960	6	.4796
b_5	9	.0567	3	.0510

independent variables. Based on trial and error we decided to use a critical region determined by values greater than 2.3. The lower the value of VIF the lower the degree of collinearity among the explanatory variables.

Based on this final criterion, we chose the following five independent variables for the first beta:

1. Total liabilities to equity (TLTOE);
2. Total assets turnover (TATOV);
3. Net fixed assets per employee (NFAPEREM);
4. Natural log of sales (REVENUE); and,
5. Market to book value (MRKTOBKV).

Among these variables, net fixed assets per employee (NFAPEREM) carries the highest VIF of 1.28. In other words if we use TLTOE, TATOV, REVENUE and MRKTOBKV as the independent variables in a regression model to explain NFAPEREM, the R^2 will be close to 22 per cent. Therefore, multicollinearity does not seem to be severe for this model specification.

We use the following three variables to make predictions for the second beta:

1. Gross margin (GRSMRG);
2. Variability of earnings (VEBIT); and,
3. Natural log of sales (REVENUE).

The highest variance inflation factor is 1.10 for variability of earnings (VEBIT). Based on (4.1), the R^2 associated with this level of VIF is approximately 9%.

The least collinear variables that we can use in order to make predictions for the third beta are the following:

1. Collection period (COLPERD);
2. Return on total assets (REOTA);
3. Variability of earnings (VEBIT);
4. Net fixed assets per employee (NFAPEREM); and,
5. Market to book value (MRKTOBKV).

Market to book value has the highest VIF in this model, amounting to 1.69 (R^2=0.41).

We use the following six least-collinear accounting variables for the fourth APT risk measure:

1. Current ratio (CR);
2. Working capital turnover (WCTOV);
3. Collection period (COLPERD);
4. Total assets turnover (TATOV);
5. Net fixed assets turnover (NFXASTOV); and,
6. Net fixed assets per employee (NFAPEREM).

The highest variance inflation factor is 2.21 (R^2=0.55) which corresponds to total assets turnover (TATOV).

For the fifth estimated APT risk measure we use two variables, net fixed assets per employee (NFAPEREM) and REVENUE. The collinearity between the two of them is reflected in a variance inflation factor of 1.18.

Table 4.3 reports the results of the regression analysis. Examination of the coefficients of determination reveals that traditional accounting risk measures are very good candidates for explaining the cross-sectional variation of the first beta. The adjusted R^2 is 0.643. For the second and fourth estimated betas, the explanatory power is close to 50 per cent. One fifth of the variation of the third APT risk sensitivity is explained in the regression model that uses financial accounting risk measures. Finally, a relatively small part of the variability of the fifth beta - 5.10 per cent - is explained by a regression model that uses financial variables.

The first of the estimated betas appears to be driven most by traditional accounting risk measures. Based on the signs of the estimated regression coefficients, there are two major, opposite, forces determining cross-sectional variability. On the one hand, we have sales (REVENUE) and market to book value (MRKTOBKV); On the other hand, we have net fixed assets per employee (NFAPEREM), total assets turnover (TATOV), and total liabilities to equity (TLTOE). In other words, we have a contrast between size/market power versus capital intensiveness and financial leverage structure.

TABLE 4.3

Results of the Regression
of Arbitrage pricing Theory Risk Measures on
Traditional Accounting Risk Measures

(373 Companies from the 1983-1986 period)

b_1	Ind. Variables	Coefficient	St. Error	p-value
	TLTOE	-0.0325	0.0070	0.0001
	TATOV	-0.0689	0.0101	0.0001
	NFAPEREM	-0.0007	0.0001	0.0001
	REVENUE	0.0613	0.0025	0.0001
	MRKTOBKV	0.0262	0.0041	0.0001
	Adj.R^2=0.6431	VIF(NFAPEREM)=1.28		
b_2	Ind. Variables	Coefficient	St. Error	p-value
	GRSMRG	-0.1517	0.0333	0.0001
	VEBIT	-0.7400	0.2266	0.0012
	REVENUE	-0.0472	0.0025	0.0001
	Adj.R^2=0.4930	VIF(VEBIT)=1.10		
b_3	Ind. Variables	Coefficient	St. Error	p-value
	COLPERD	-0.0008	0.0003	0.0018
	REOTA	0.5583	0.1556	0.0004
	VEBIT	-0.9060	0.2542	0.0004
	NFAPEREM	0.0003	0.0001	0.0012
	MRKTOBKV	-0.0254	0.0059	0.0001
	Adj.R^2=0.2012	VIF(MRKTOBKV) =1.69		

TABLE 4.3 cont'd

Results of the Regression
of Arbitrage pricing Theory Risk Measures on
Traditional Accounting Risk Measures

(373 Companies from the 1983-1986 period)

b_4	Ind. Variables	Coefficient	St. Error	p-value
	CR	0.0140	0.0036	0.0001
	WCTOV	0.0007	0.0003	0.0263
	COLPERD	0.0010	0.0002	0.0001
	TATOV	0.0433	0.0122	0.0004
	NFXASTOV	0.0045	0.0015	0.0023
	NFAPEREM	0.0014	0.0001	0.0001
	Adj.R^2=0.4796	VIF(TATOV)=2.21		
b_5	Ind. Variables	Coefficient	St. Error	p-value
	NFAPEREM	0.0002	0.0001	0.0763
	REVENUE	-0.0120	0.0026	0.0001
	Adj.R^2=0.0510	VIF=1.18		

Looking at the estimated regression equation for the second APT risk measure we see that it is based on sales (REVENUE), variability of earnings (VEBIT), and gross profit margin (GRSMRG). All enter the model with the same sign.

A regression model using five financial accounting risk measures explains 20 per cent of the variation of the third beta. The set of explanatory variables can be divided in two sets based on their signs. The first group contains a profitability ratio - return on total assets (REOTA) - and a business risk ratio - net fixed assets per employee (NFAPEREM). Both have a positive sign, and so have a direct, same-direction influence on the third beta. The rest of the explanatory variables - collection period (COLPERD), variability of earnings (VEBIT), and market to book value (MRKTOBKV) - all with negative signs, obviously are inversely related to the third beta.

In the fourth estimated beta model, the liquidity ratios (CR, WCTOV, and COLPERD), turnover ratios (TATOV and NFXASTOV), and the capital intensiveness measurement (NFAPEREM) are statistically significant. The regression model accounts for 47.96 per cent of the adjusted variation of fourth estimated beta.

Examination of the regression model for the fifth beta reveals that a measure of size (REVENUE) is the only explanatory variable that is statistically significant at the 5 per cent level of significance. Based on the sign of the estimated regression coefficient, sales (REVENUE) is inversely associated with the fifth APT risk measure. The regression model accounts for 5.1 per cent of the variations of the fifth beta.

The empirical results of our analysis support the results of the MEH study. Due to the nature of the statistical analysis used for estimating betas and the formulation of the APT theory, it is not easy to relate the betas with pervasive risk factors. In spite of this, both studies seem to reach a common conclusion. MEH showed that, "The second sensitivity measure is quite clearly a size of firm (sale) factor, as well as capital intensiveness factor." The authors report that the R^2 for this factor is 73 percent in their study. Revenue and capital intensiveness also dominate in the first of the estimated betas in our study; the adjusted R^2 is 65 percent.

Both studies identify a risk sensitivity (beta) which is explained by traditional accounting risk measures such as sales and capital intensiveness. In the MEH study, both accounting risk measures enter the regression model with the same sign, while in our study the variables enter the model with opposite signs.

3. Analysis of the Residuals

Examination of the residuals for all 5 betas revealed them to be approximately normally distributed with a mean equal to zero and a rather constant variance. One of the assumptions of the linear model, non auto-correlated residuals (zero covariance among the error terms), is violated, however.

This violation becomes clear after we rank the residuals by the estimated beta in each model. Table 4.4 reports the autocorrelations for the ranked residuals corresponding to each one of the beta prediction models. There is a very strong positive correlation among the residuals across all models. The model that seems to have the least autocorrelated residuals is the first one (u_{b1}), while the fifth one (u_{b5}) seems to be the one with the highest. It should be noted that the model corresponding to the first beta has the highest explanatory power, while the fifth has the lowest. A similar problem was detected by Beaver *et al.* (1970).[5] When studying cross section data, autocorrelated residuals imply that the error term value that is extracted for any one unit is influenced by the residual values extracted from the other units.

According to Johnston (1972), the assumption of zero covariance among the residuals may not be plausible due to any one or more of the following problems:

1. Incorrect specification of the structural form of the association between the dependent and independent variables;
2. One or more important explanatory variable missing from the specified model; and/or,
3. Measurement error in the explained variable.[6]

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[5] Beaver et al. (1970), pp. 676-77

[6] Johnston (1972), p. 243.

TABLE 4.4

Autocorrelation Analysis of Residuals of the Regressions of the Arbitrage Pricing Theory Risk Measures on Traditional Accounting Risk Measures

373 Companies from the 1983-1986 Period

Lag	u_{b1}	u_{b2}	u_{b3}	u_{b4}	u_{b4}
1	0.31	0.57	0.771	0.666	0.828
2	0.349	0.566	0.756	0.588	0.697
3	0.333	0.554	0.751	0.574	0.584
4	0.259	0.491	0.734	0.551	0.481
5	0.347	0.496	0.726	0.55	0.477
6	0.302	0.521	0.688	0.529	0.474
7	0.27	0.492	0.681	0.498	0.446
8	0.28	0.504	0.678	0.525	0.449
9	0.275	0.442	0.646	0.546	0.431
10	0.276	0.478	0.619	0.518	0.418
11	0.234	0.463	0.62	0.433	0.423
12	0.297	0.456	0.624	0.459	0.42
13	0.312	0.454	0.586	0.47	0.416
14	0.313	0.44	0.569	0.491	0.422
15	0.329	0.385	0.545	0.488	0.405
16	0.29	0.433	0.564	0.474	0.403
17	0.306	0.415	0.54	0.507	0.398
18	0.216	0.389	0.514	0.505	0.381
19	0.346	0.426	0.519	0.472	0.369
20	0.289	0.408	0.515	0.48	0.36
Skewness	-0.755	-0.046	-0.227	0.536	-3.755
Kurtosis	1.564	-0.158	0.798	4.424	26.770
W:Normal	0.966	0.984	0.984	0.979	0.749
Pr<W	0.000	0.421	0.460	0.088	0.000

Note: $u_{bi's}$ are the auto-correlations corresponding to the ranked by b_i residuals produced from the model used to predict/explain the i^{th} APT risk measure. Analysis of the normality of residuals is performed by examining the skewness, kurtosis as well as through the Kolmogorov's D test

In regard to the specification of the structural form; the question is, 'can we justify and empirically test non linear associations between accounting risk measures and betas?' The answer to this question is negative because APT does not specify the nature of the pervasive risk factors. Authors who studied the association between financial accounting variables and market risk developed alternative non-linear specifications for the structural relation. Unfortunately, it is impossible to establish theoretically the existence of similar specifications in the case of the APT model. In a search for any non-linear relationship; the plotting of betas versus each one of the financial accounting variables did not indicate any other pattern of association between estimated betas and traditional accounting risk measures than the linear one.
The second problem that may cause non-zero covariance among the residuals are missing explanatory variables in the model specification. It is reasonable to assume that many other non-accounting variables may determine the estimated APT risk measures. However, it is not easy to account for and use them in a regression model. Again, we rely on the studies of accounting risk measures and market risk regarding CAPM.

Logue and Merville (1972) argue that market risk depends on all characteristics by which firms may be compared. As such, the authors referred to a firm's financial, marketing, and production policy, as well as any other corporate policy decisions that may be used for inter-firm comparisons. Logue and Merville, as well as most of the other studies in this area, carried out their empirical analysis using only the financial accounting variables because the influence of the other policies on market risk is "partially reflected in the financial policy of the firm."[7]

In another study, Bildersee (1975) examined the relation between the CAPM market risk and accounting variables as well as corporate decisions. Corporate decisions would include such things as a change in dividend policy. Bildersee concludes that "... addition of a set of decision variables to accounting data could increase our chance to observe a useful association between traditional measures of risk and beta."[8]

Therefore, it is plausible that some relatively important explanatory variables may be missing from our regression model. These may be either some new ingenious combination of the already existing financial statement data or some other variables from outside the realm of financial statement analysis. Cash flow specifications of accounting risk measures have been found to enhance the explanatory power of models predicting market risk in the CAPM model. Later, in part seven of this chapter, we examine the potential increase in explanatory power of the beta predicting models from introducing cash flow based risk measures in our analysis.

The final possible cause of autocorrelated residuals, according to Johnston, is measurement error for the explained variable. Given the fact that we cannot observe the real APT risk measures, it is natural to expect that the estimated betas through factor analysis may be measured with some error. In other words,

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[7]Logue and Merville (1972):40

[8] Bildersee (1975), pp. 94, 96.

$$b_j = \beta_j + u_j$$

where,

β_j is the true but unobserved APT risk measure that corresponds to the j^{th} risk factor;

b_j is the estimated beta; and,

u_j is the error term.

We assume that b_j is an unbiased estimator of β_j; i.e., $E(b_j) = \beta_j$.

Apparently given the association between the estimated and real beta, we may have:

$$u_j > 0 \quad <==> \quad b_j - \beta_j > 0 \quad <==> \quad b_j > \beta_j$$

$$u_j < 0 \quad <==> \quad b_j - \beta_j < 0 \quad <==> \quad b_j < \beta_j$$

This implies that whenever the actual beta is larger than the estimated one, the residual will tend to be positive. The residuals will tend to be negative whenever the estimated beta value is less than the actual one.

The following argument from the study of Beaver et al. (1970) captures the spirit of the problem and its implications for our analysis;

> " ... if β_1 is measured with error, the lowest b_1 values are more likely to contain a negative error term and the largest values a positive one. If the instrumental equation is fulfilling its purpose, positive correlation in error terms should be expected."[9]

A simple way to account for this measurement error problem is through the creation of portfolios. Using portfolios we hope to create an expected measurement

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[9] Beaver et al. (1970): 677. The term in this quote "*Instrumental equation*" refers to the expression of beta as a function of the accounting risk measures.

error equal to zero. By construction, portfolios combine more than one individual security. Therefore instead of using the original data for the estimated betas and accounting risk measures, the observations are arranged in groups/portfolios, and only the group means for each variable are given. As a result of this procedure, we hope to attain a wash-out of the measurement errors within each group/portfolio.[10]

In the following section, we examine the validity of the tested hypothesis using portfolios instead of individual securities. We carry out multiple regression analysis using group/portfolio data for both the dependent variables (b_i's) and independent variables (accounting risk measures).

4. Portfolio Analysis

Analysis of the ability of accounting risk measures to explain the cross-sectional variation of APT risk measures at the portfolio level has practical merit beyond the econometric considerations. Investors are more interested in the behavior of large groups of stocks (mutual funds) and predictions of risk at the portfolio level.

There are two problems associated with the use of grouped data in place of individual observations.[11] First, the variances of the coefficients tend to be larger (inefficient). Second, the residuals tend to be heteroscedastic.

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[10]The underlying assumption during the portfolio analysis is that the signs of the measurement errors will be randomly distributed in each group/portfolio.

[11]For a detailed analysis on the properties of regression analysis with grouped data see Johnston (1972), pp. 228-232.

According to Johnson (1972) the inefficiency problem is minimized by grouping the data after ranking the observations according to the size of the explanatory variable. Since sales (REVENUE) seems to be the most influential explanatory variable in the set of accounting risk variables, we decided to rank individual stocks for the creation of groups/portfolios by the size of sales.

According to Johnson (1972), the problem of heteroscedasticity can be avoided by creating groups that contain the same number of observations. For our analysis, we decided to use five individual companies in each group/portfolio. The choice was guided by the size of portfolios of similar studies in the past.

The outline of the portfolios creation procedure is as follows. First, the companies in the sample were ranked based on their volume of sales. The data were then grouped into portfolios of five companies each. The first portfolio was comprised of those five companies with the smallest volumes of sales. The rest of the portfolios were formed in a similar manner, producing a total number of seventy four portfolios. Third, for each group/portfolio, we estimated the mean of every dependent and independent variable.

The choice of the independent variables in each model was made by

TABLE 4.5

Number of Independent Variables
and Corresponding Coefficients of Determination
After the First and Second Criterion

	First Criterion		Second Criterion	
	Independent Variables	Adjusted R^2	Independent Variables	Adjusted R^2
b_1	10	0.8933	5	0.8826
b_2	13	0.7947	3	0.7250
b_3	10	0.4323	4	0.4162
b_4	10	0.7102	5	0.6816
b_5	6	0.3873	3	0.3285

repeating the stepwise regression procedure described earlier. Once again, as it was found at the individual security level, we find that with small sacrifices in the explanatory power we end up using simpler models. The results of the stepwise regression procedure appear in table 4.5.

As it was expected, the explanatory power is higher for all of the regression models at the portfolio level, though the coefficients of determination should be seen as having value distinct from their serving as comparative levels to be used in evaluating the two methods.[12]

The results of the regression analysis using portfolios appear in Table 4.6. For the first of the estimated betas, the use of five accounting risk measures in the regression model accounts for 88.26 per cent of its variability. The variables used in the model are the same variables that were reported as significant at the individual security level; namely,[13] liabilities to equity (TLTOE), total assets turnover (TATOV), net fixed assets per employee (NFAPEREM), natural log of sales (REVENUE), and market to book value (MRKTOBKV). The only difference is that the variable total liabilities to equity (TLTOE) is only marginally significant at the portfolio level. Besides this minor difference, the first estimated APT risk measure continues to reflect the contrast between revenues and market power versus capital intensiveness and financial leverage structure.

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[12]"... the R^2 computed from grouped data can often be substantially greater than the R^2 for the individual data and may be quite a misleading indicator of the latter." Johnston (1972): 230.

[13]The collinearity among the explanatory variables at the portfolio level is higher. The highest VIF corresponds to NFAPEREM and it is 2.00 (R^2=50 per cent).

TABLE 4.6
Results of the Regression Analysis
of Arbitrage Pricing Theory Risk Measures on
Traditional Accounting Risk Measures

74 Portfolios from the 1983-1986 Period

b1	Ind. Variables	Coefficient	St. Error	p-value
	TLTOE	-0.0248	0.0165	0.1366
	TATOV	-0.1075	0.0228	0.0001
	NFAPEREM	-0.0012	0.0002	0.0001
	REVENUE	0.0662	0.0032	0.0001
	MRKTOBKV	0.0289	0.0096	0.0037
	Adj.R^2=0.8826 VIF(NFAPEREM)=2.01			
b2	**Ind. Variables**	**Coefficient**	**St. Error**	**p-value**
	GRSMRG	0.3036	0.1175	0.0119
	TATOV	0.1132	0.0333	0.0011
	REVENUE	-0.0412	0.0034	0.0001
	Adj.R^2=0.7250 VIF(GRSMRG)=1.28			
b3	**Ind. Variables**	**Coefficient**	**St. Error**	**p-value**
	COLPERD	-0.0018	0.0004	0.0001
	EXPTOREV	-0.8272	0.2199	0.0003
	VSALES	-0.2935	0.0823	0.0007
	MRKTOBKV	-0.0251	0.0106	0.0209
	Adj.R^2=0.4162 VIF(MRKTOBKV)=1.37			
b4	Ind. Variables	Coefficient	St. Error	p-value
	COLPERD	0.0014	0.0005	0.0062
	TATOV	0.092	0.0249	0.0004
	NFAPEREM	0.0023	0.0002	0.0001
	REVENUE	-0.0143	0.0033	0.0001
	CASH	0.1027	0.0393	0.0111
	Adj.R^2=0.6816 VIF(REVENUE)=2.43			
b5	Ind. Variables	Coefficient	St. Error	p-value
	INVTOWC	-0.0137	0.0044	0.003
	VSALES	-0.1112	0.0734	0.1343
	REVENUE	-0.0088	0.0024	0.0004
	Adj.R2=0.3285 VIF(INVTOWC)=1.20			

The regression model predicting the second beta, using gross margin (GRSMRG), total assets turnover (TATOV), and sales (REVENUE), has an adjusted R^2 equal to 72.5 per cent. Gross margin and assets turnover describe this APT risk measure with positive signs. The sign of revenue is negative. Comparison between the results at individual and portfolio level reveals that gross margin has a positive influence on the second beta at the portfolio level and an inverse influence on the individual firm level.

In regard to the third beta, collection period (COLPERD) and market to book value (MRKTOBKV) are stable variables in the sense that they appear with the same sign and they are significant at both the individual and portfolio level. The other two new explanatory variables at portfolio level are expenses to revenue (EXPTOREV), and variability of sales (VSALES). All the explanatory variables enter the regression model for the third APT risk measure with the same negative sign. The explanatory power of the model is close to 42 per cent.

The regression model using five accounting risk measures accounts for 68.16 per cent of the variability of the fourth beta. The explanatory variables used are collection period (COLPERD), assets turnover (TATOV), fixed assets per employee (NFAPEREM), sales (REVENUE) and cash (CASH). With the exception of sales all the other variables have a positive influence on the fourth APT risk measure.

Finally, the model based on the inventory to working capital (INVTOWC), variability of sales (VSALES), and sales (REVENUE), accounts for approximately one third of the variability of the fifth beta. Revenue is the only variable which is significant both at the individual and portfolio level.

Analysis of the estimated residuals indicated that all of them are approximately normally distributed with a mean equal to zero and fairly constant variance. Regarding the co-variation of errors, the results of the autocorrelation analyses appear in Table 4.7. The estimated measures of autocorrelation are low for the first of the estimated betas. For the rest of the estimated betas, the residuals continue to be positively correlated, though to a lesser degree than that reported at the individual level.

Overall, the regression analysis results at portfolio level reinforce our previous findings based on correlation and multiple regression analysis at the individual security level. Accounting measures posses an impressive explanatory power over the first, second and fourth APT risk measures. Their explanatory power is relatively lower, though still substantial, when considering the third and fifth betas.

In the following section, we introduce another specification of accounting risk measures in to our set of independent variables. Namely, we examine the impact on the explanatory power of our models by introducing cash flow based risk measures.

5. Cash Flow Based Risk Measures

As was mentioned in chapter III, primitive forms of cash flow statements date back to the second half of the 19th century, but they were not required in

TABLE 4.7

Autocorrelation Analysis of Residuals
of the Regressions of Arbitrage Pricing Theory Risk Measures
on Traditional Accounting Risk Measures

74 Portfolios from the 1983-1986 Period

Lag	u_{b1}	u_{b2}	u_{b3}	u_{b4}	u_{b4}
1	-0.0890	0.2430	0.3730	0.2500	0.5050
2	0.0840	0.3390	0.3800	0.0530	0.5370
3	0.0140	0.3000	0.4300	-0.0170	0.4200
4	0.2770	0.3820	0.4120	0.1950	0.3420
5	-0.1390	0.2050	0.2770	0.3130	0.4040
6	0.1000	0.2340	0.3920	0.1170	0.3680
7	0.2220	0.0900	0.2260	0.1010	0.3300
8	-0.2000	0.2050	0.1910	-0.0900	0.3700
9	0.0000	0.1120	0.0920	0.1070	0.3030
10	0.0530	0.0210	0.1630	-0.0970	0.2710
11	0.0770	0.1320	0.1270	0.1230	0.2560
12	-0.1800	0.0400	0.1530	0.2090	0.2380
13	0.0520	0.0290	0.1460	0.1580	0.2130
14	0.1490	-0.0620	0.1420	-0.0110	0.2380
15	-0.0550	-0.0520	-0.0260	-0.1370	0.1960
16	-0.0380	-0.0680	0.0860	-0.0080	0.2020
17	0.0250	-0.0580	0.1540	0.0730	0.1270
18	0.1020	-0.2270	0.0570	0.0400	0.1480
Skewness	-0.233	-0.476	-0.124	0.448	-0.698
Kurtosis	-0.588	-0.076	0.651	2.075	3.186
W:Normal	0.961	0.967	0.990	0.980	0.951
Pr<W	0.073	0.157	0.967	0.609	0.016

Note: $u_{bi's}$ are the lagged auto-correlations corresponding to the ranked by b_i residuals produced from the model used to explain the i^{th} APT risk measure. Analysis of the normality of the residuals is performed by examining the skewness, kurtosis as well as through the Kolmogorov's D test corporate financial statements until 1988. The widespread use of cash flow ratios in financial statement analysis as a measure of risk started when Beaver (1966) found that one of the best single ratios for predicting bankruptcy was the cash flow to long term debt. In a recent study, Ismail and Kim (1989) found that cash flow based risk measures yield additional explanatory power, over that contributed by the earnings risk, measures in explaining the cross-sectional variability in market betas.

The incorporation of cash flow based risk measures in our data set works as another constraint further narrowing the sample size. Due to the lack of data in COMPUSTAT, and constraints from the definitions, the original sample size of 373 companies was reduced to 276. Table 4.8 summarizes the simple statistics of the estimated betas, as well as the cash flow based risk measures, for this new sample.

The predictive correlation analysis (Table 4.9) reveals that profitability and efficiency cash flow based risk measures (CFOTA, CFOE, CFOMRG) are significantly correlated with most of the estimated APT risk measures. With the exception of the first beta, CFOD does not seem to be significantly related to the APT risk measures.

We also carried out the stepwise regression procedure on the new sample. The results led to the same variables being chosen for each estimated beta as had been determined for the original data set. No substantial influences were observed as a result of incorporating the cash flow based risk measures. This finding, plus the results of the correlation analysis among the cash flow based risk measures, directed us to examine the following model

TABLE 4.8

Simple Statistics
of the Estimated Arbitrage Pricing Theory Risk Measures and
Cash Flow Based Traditional Accounting Risk Measures

276 Companies from the (1983-1986 Period)

VARIABLE	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
b_1	0.353	0.132	0.063	0.706
b_2	0.025	0.123	-0.319	0.283
b_3	0.008	0.104	-0.354	0.286
b_4	0.013	0.106	-0.152	0.621
b_5	0.009	0.063	-0.462	0.162
CFOTA	0.12	0.058	0.003	0.308
CFOD	2.133	4.352	0.019	42.372
CFOE	0.23	0.119	0.005	0.744
CFOMRG	0.098	0.061	0.003	0.422

TABLE 4.9

Correlation Analysis
Among Arbitrage Pricing Theory Risk Measures
and Cash Flow Based Traditional Accounting Risk Measures

276 Companies from the 1983-1986 Period

	b_1	b_2	b_3	b_4	b_5
CFOTA	0.36	-0.281	-0.019	0.01	0.119
CFOD	0.163	-0.092	-0.015	-0.064	0.069
CFOE	0.296	-0.296	-0.013	0.049	0.138
CFOMRG	0.33	-0.257	-0.117	-0.001	0.135

TABLE 4.10

Correlation Analysis
Among Cash Flow Based Traditional Accounting Risk Measures

276 Companies from the 1983-1986 Period

	CFOTA	CFOD	CFOE	CFOMRG
CFOD	0.385	1.000	0.249	0.246
CFOE	0.853	0.249	1.000	0.659
CFOMRG	0.801	0.246	0.659	1.000

TABLE 4.11

Results of the Regression Analysis
of Arbitrage Pricing Theory Risk measures on a Set of Traditional
Accounting Risk measures that Includes Cash Flow Based Risk Measures

(276 Companies from the 1983-1986 period)

b_1	IND. VARIABLE	COEFFICIENT	ST. ERROR	p-VALUE
	TLTOE	-0.0145	0.0083	0.0814
	TATOV	-0.0823	0.0111	0.0001
	NFAPEREM	-0.0008	0.0001	0.0001
	REVENUE	0.0613	0.003	0.0001
	MRKTOBKV	0.0309	0.005	0.0001
	Adj.R^2=0.6463 VIF(NFAPEREM)= 1.35			
b_2	IND. VARIABLE	COEFFICIENT	ST. ERROR	p-VALUE
	GRSMRG	-0.1665	0.035	0.0001
	VEBIT	-0.8023	0.2513	0.0016
	REVENUE	-0.0543	0.0028	0.0001
	Adj.R^2=0.5844 VIF(GRSMRG)=1.06			
b_3	IND. VARIABLE	COEFFICIENT	ST. ERROR	p-VALUE
	COLPERD	-0.001	0.0003	0.0006
	REOTA	0.7196	0.1851	0.0001
	VEBIT	-1.1235	0.2965	0.0002
	NFAPEREM	0.0003	0.0001	0.0062
	MRKTOBKV	-0.0349	0.0074	0.0001
	Adj.R^2=0.2807 VIF(MRKTOBKV)=1.91			

TABLE 4.11 Cont'd

Results of the Regression Analysis of Arbitrage Pricing Theory Risk measures on a Set of Traditional Accounting Risk measures that Includes Cash Flow Based Risk Measures

(276 Companies from the 1983-1986 period)

b_4	IND. VARIABLE	COEFFICIENT	ST. ERROR	p-VALUE
	CR	0.0117	0.0044	0.0088
	WCTOV	0.0007	0.0003	0.0455
	COLPERD	0.0012	0.0003	0.0001
	TATOV	0.0481	0.0145	0.0011
	NFXASTOV	0.0052	0.002	0.0096
	NFAPEREM	0.0015	0.0001	0.0001
	Adj.R^2=0.5259 VIF(TATOV)=2.27			
b_5	IND. VARIABLE	COEFFICIENT	ST. ERROR	p-VALUE
	NFAPEREM	0	0.0001	0.6757
	REVENUE	-0.0046	0.0023	0.0536
	Adj.R^2=0.0071 VIF=1.23			

TABLE 4.12

Results of the Regression Analysis of
Arbitrage Pricing Theory Risk Measures on a Set of
Traditional Accounting Risk Measures that Includes
Cash Flow Based Risk measures (CFOTA is included)

(276 Companies from the 1983-1986 period)

b_1	Ind. Variables	Coefficients	St. Error	p-value
	TLTOE	-0.0125	0.0084	0.1354
	TATOV	-0.0827	0.0111	0.0001
	NFAPEREM	-0.0008	0.0001	0.0001
	REVENUE	0.0596	0.0031	0.0001
	MRKTOBKV	0.0276	0.0054	0.0001
	CFOTA	0.1517	0.0928	0.103
	Adj.R^2=0.6485 VIF(REVENUE)=1.39			
b_2	Ind. Variables	Coefficients	St. Error	p-value
	GRSMRG	-0.1605	0.0364	0.0001
	VEBIT	-0.7971	0.2517	0.0017
	REVENUE	-0.0538	0.0029	0.0001
	CFOTA	-0.0537	0.089	0.5471
	Adj.R^2=0.5835 VIF(CFOTA)=1.17			

TABLE 4.12 Cont'd

Results of the Regression Analysis of
Arbitrage Pricing Theory Risk Measures on a Set of
Traditional Accounting Risk Measures that Includes
Cash Flow Based Risk measures (CFOTA is included)

(276 Companies from the 1983-1986 period

b_3	**Ind. Variables**	**Coefficients**	**St. Error**	**p-value**
	COLPERD	-0.001	0.0003	0.0005
	REOTA	0.8417	0.2058	0.0001
	VEBIT	-1.1617	0.2974	0.0001
	NFAPEREM	0.0003	0.0001	0.0032
	MRKTOBKV	-0.0339	0.0074	0.0001
	CFOTA	-0.1488	0.1103	0.1787
	Adj.R^2=0.2829 VIF(REOTA)=1.99			
b_4	Ind. Variables	Coefficients	St. Error	p-value
	CR	0.0121	0.0045	0.0082
	WCTOV	0.0007	0.0003	0.0443
	COLPERD	0.0012	0.0003	0.0001
	TATOV	0.0483	0.0146	0.001
	NFXASTOV	0.0052	0.002	0.0091
	NFAPEREM	0.0015	0.0001	0.0001
	CFOTA	0.0309	0.0777	0.6912
	Adj.R^2=0.5244 VIF(TATOV)=2.28			
b_5	**IND. VARIABLE**	**COEFFICIENT**	**ST. ERROR**	**p-VALUE**
	NFAPEREM	0	0.0001	0.5895
	REVENUE	-0.0062	0.0024	0.0101
	CFOTA	0.1753	0.0661	0.0085
	Adj.R^2=0.0286 VIF(REVENUE)=1.32			

specifications. First, we ran the regression analysis using the original set of independent variables. Subsequent to this, we added cash flow to total assets (CFOTA) to the right hand side of the model.[14]

The regression analysis results reported in Table 4.11 indicate that using the new sample produced exactly the same results that we had with the original data set. Cash flow to total assets is statistically significant for the fifth beta (table 4.12), though its additional explanatory power is marginal. Hence, cash flow based risk measures do not add to the explanatory power of the models.

6. Comparative Analysis of the Regression Analyses Results

In this last part of this chapter, we bring together the regression results for each beta across different sample specifications. More specifically, we compare the regression results for each estimated beta based on the original sample (373 companies), the portfolio sample (74 portfolios of 5 companies each), and the cash flow based sample (276 companies).

Tables 4.13 through 4.17 summarize the regression results. Examination of comparative results of the first beta (Table 4.13) reveals that the first APT risk measure captures the contrast between two forces: liabilities to equity (TLTOE), asset turnover (TATOV), and fixed assets per employee (NFAPEREM) versus sales

[14]We do not report the results of the regression analysis with rest of the cash flow based risk measures (CFOE, CFOMRG), since they can be seen as surrogates of cash flow to total assets (CFOTA). This argument is supported by the high degree of correlation among the three cash flow based profitability/efficiency risk measures. The correlations among the cash flow based risk measures appear in table 4.8.

(REVENUE) and market to book value (MRKTOBKV). The first set, with a negative sign, implies an inverse influence; while the second one, with a positive sign, implies a positive influence on the formulation of the first risk measure. Interestingly, the signs seem to be in accordance with the original hypotheses that sales (REVENUE) and market to book value (MRKTOBKV) would be inversely related to risk while liabilities to equity (TLTOE) and fixed assets per employee (NFAPEREM) are assumed to be directly proportional to risk. Unfortunately, this analogy between theoretical and empirical evidence does not hold for total assets turnover. By construction the total assets turnover (TATOV) - defined as the ratio of sales to total assets will bear an inverse relation to risk. Therefore, we would have expected its regression coefficient to be similar to that of sales (REVENUE) and market to book value (MRKTOBKV).

Hence, financial accounting risk variables representing the contrast between revenue/market power versus financial and operating leverage describe the first estimated APT risk measure. The explanatory power is significant across different sample specifications.

For the rest of the estimated betas, the results are not as clear and the explanatory power fluctuates from sample to sample. Models used to predict the second APT risk measure reveal that gross profit margin (GRSMRG), variability of earnings (VEBIT), and sales are the three major explanatory variables. These three accounting risk measures collectively account for almost half or more of the variability of the second beta. Comparative analysis across samples (Table 4.14) reveals that only revenue and variability of earnings seem to enter all the models with the same sign. For the profit margin, we find that it enters the prediction model with negative sign at the individual level and positive sign at the portfolio level.

The comparative results of the third beta are summarized in Table 4.15. In each sample, the collection period (COLPERD) carries an inverse relation with the third APT risk measure across all samples. Other significant variables are the two measures of business risk (VSALES, VEBIT) and the market to book value (MRKTOBKV).

Table 4.16 summarizes the regression results for the fourth beta. Three variables consistently appear across all sample specifications exercising a positive proportional influence over the fourth beta. The variables are, collection period (COLPERD), total assets turnover (TATOV), and net fixed assets per employee (NFAPEREM).

Sales is the only stable (common influence across samples) variable when dealing with the fifth beta. With the exception of the portfolio level regressions, the explanatory power of regressions for the fifth beta is small.

The regression analysis results at portfolio level do reinforce our previous findings. Accounting risk measures by themselves are considered adequate in describing the first estimated APT risk measure. They also carry a considerable explanatory power over the second and fourth one. The specifications of accounting risk measures that we use in this study are not adequate in explaining the third and fifth APT risk measures. For the two of them, we ought to experiment either with alternative specifications of accounting risk measures or alternative functional forms relating them with the accounting risk measures.

In this chapter, we have seen that traditional accounting risk measures can be used to explain estimated APT risk measures across different sample specifications. In the following chapter, we test whether this finding will hold with more recent data.

TABLE 4.13
Comparison of Regression Results for b_1, 1983-1986 Period

Variable	Individual n=373	Portfolios n=74	Cash Flow n=276
CR			
QR			
WCTOV			
COLPERD			
INVTOV			
DRTINWC			
INVTOCA			
INVTOWC			
TLTOTA			
TLTOE	(-)*	(-)***	(-)**
DTONFXAS			
COVERAGE			
GRSMRG			
REOTA			
REOE			
TATOV	(-)*	(-)*	(-)*
NFXASTOV			
EXPTOREV			
VEBIT			
VSALES			
NFAPEREM	(-)*	(-)*	(-)*
REVENUE	(+)*	(+)*	(+)*
PEREXCL			
DPOUT			
MRKTOBKV	(+)*	(+)*	(+)*
CASH			
PM			
Adjusted R^2	0.6431	0.8826	0.6463

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 4.14
Comparison of Regression Results for b_2, 1983-1986 Period

Variable	Individual n=373	Portfolios n=74	Cash Flow n=276
CR			
QR			
WCTOV			
COLPERD			
INVTOV			
DRTINWC			
INVTOCA			
INVTOWC			
TLTOTA			
TLTOE			
DTONFXAS			
COVERAGE			
GRSMRG	(-)*	(+)*	(-)*
REOTA			
REOE			
TATOV		(+)*	
NFXASTOV			
EXPTOREV			
VEBIT	(-)*		(-)*
VSALES			
NFAPEREM			
REVENUE	(-)*	(-)*	(-)*
PEREXCL			
DPOUT			
MRKTOBKV			
CASH			
PM			
Adjusted R^2	0.4930	0.7250	0.5844

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 4.15
Comparison of Regression Results for b_3, 1983-1986 Period

Variable	Individual n=373	Portfolios n=74	Cash Flow n=276
CR			
QR			
WCTOV			
COLPERD	(-)*	(-)*	(-)*
INVTOV			
DRTINWC			
INVTOCA			
INVTOWC			
TLTOTA			
TLTOE			
DTONFXAS			
COVERAGE			
GRSMRG			
REOTA	(+)*		(+)*
REOE			
TATOV			
NFXASTOV			
EXPTOREV		(-)*	
VEBIT	(-)*		(-)*
VSALES		(-)*	
NFAPEREM	(+)*		(+)*
REVENUE			
PEREXCL			
DPOUT			
MRKTOBKV	(-)*	(-)*	(-)*
CASH			
PM			
Adjusted R^2	0.2012	0.4162	0.2807

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 4.16
Comparison of Regression Results for b_4, 1983-1986 Period

Variable	Individual n=373	Portfolios n=74	Cash Flow n=276
CR	(+)*		(+)*
QR			
WCTOV	(+)*		(+)*
COLPERD	(+)*	(+)*	(+)*
INVTOV			
DRTINWC			
INVTOCA			
INVTOWC			
TLTOTA			
TLTOE			
DTONFXAS			
COVERAGE			
GRSMRG			
REOTA			
REOE			
TATOV	(+)*	(+)*	(+)*
NFXASTOV	(+)*		(+)*
EXPTOREV			
VEBIT			
VSALES			
NFAPEREM	(+)*	(+)*	(+)*
REVENUE		(-)*	
PEREXCL			
DPOUT			
MRKTOBKV			
CASH	(+)*		
PM			
Adjusted R^2	0.4796	0.6816	0.5259

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 4.17
Comparison of Regression Results for b_5, 1983-1986 Period

Variable	Individual n=373	Portfolios n=74	Cash Flow n=276
CR			
QR			
WCTOV			
COLPERD			
INVTOV			
DRTINWC			
INVTOCA			
INVTOWC		(+)*	
TLTOTA			
TLTOE			
DTONFXAS			
COVERAGE			
GRSMRG			
REOTA			
REOE			
TATOV			
NFXASTOV			
EXPTOREV			
VEBIT			
VSALES		(-)**	
NFAPEREM	(+)**		(+)**
REVENUE	(-)*	(-)*	(-)*
PEREXCL			
DPOUT			
MRKTOBKV			
CASH			
PM			
Adjusted R^2	0.0510	0.3285	0.0071

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

CHAPTER V

EMPIRICAL ANALYSIS RESULTS
Based on the Sample Covering the 1988-1991 Period

In chapter IV, we empirically tested whether traditional accounting risk measures (TARMs) could be used to explain the cross-sectional variation of the Arbitrage Pricing Theory (APT) risk measures through correlation and regression analysis of a sample of manufacturing companies. Results of correlation analysis at the individual security level, and regression analysis, both at individual security as well as portfolio level, support our hypothesis. These results were obtained using data for a sample of manufacturing companies over the period 1983 to 1986. In this chapter, we provide additional evidence supporting our previous findings. We repeat our correlation and regression analysis using more recent data from the manufacturing industry. The new data set covers the period 1988 through 1991.

This chapter consists of four parts. The chapter opens with a brief description of the new sample. Part two contains a discussion of the predictive correlation analysis among estimated betas and accounting risk measures at the individual security level. In part three, we examine the regression analysis results at both individual company and portfolio levels. The chapter will close with a comparative discussion of the explanatory power of the accounting risk measures both across different sample specifications, as well as across the two time periods covered in this study.

1. Description of the New Sample

The new data set covers the period 1989 through 1991. More specifically, we extract daily stock returns from the CRSP files covering the period 1989 through the end of 1991. We also extracted financial accounting variables from COMPUSTAT for fiscal year 1988. Again, some of the accounting risk measure specifications require data from previous years, i.e., 1983-1987.

Two-hundred-and-ninety-two manufacturing companies met the criteria for inclusion in our sample.[1] Though the size of the sample is smaller than the one for the 1983-1986 period, it continues to be a representative one; that is, representative in the sense that all the manufacturing industries appear in the sample. Examination of the simple statistics for the estimated APT risk measures, as well as the accounting risk measures presented in table 5.1, reveals that there are not any substantial differences between these statistics for the two time periods.[2]

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[1]For the criteria that we use for including a firm in the data set, see section 2 of chapter III.

[2]As you can see from table 27, the number of companies with available data for the accounting risk measure Days Resources Tied in Working Capital (DRTINWC) is 277. This is because it was found that, for certain companies, the cost of goods sold was less than inventory. This may indicate that either the cost of goods entry is understated or the inventory is overstated. Since we could not find the underlying cause of this, we decided to drop the DRTINWC entries for these companies. The entries dropped were extremely large compared with the rest of the data set as well as the corresponding values for the DRTINWC from the 1983 data.

A similar problem - extremely large values - was found for the net fixed assets per employee (NFAPEREM) value corresponding to *United Technologies*. This net fixed assets per employee value was dropped from the sample because it was suspected that the line of business of this company may not be what we define a manufacturing company.

TABLE 5.1

Simple Statistics
For Estimated Arbitrage pricing Theory Risk Measures and
Traditional Accounting Risk Measures

(292 Companies, from the 1988-1991 Time Period)

Variable	N	Mean	Std Dev	Min	Max
b1	292	0.367	0.157	0.042	0.694
b2	292	0.037	0.13	-0.335	0.265
b3	292	0.003	0.111	-0.622	0.329
b4	292	0.011	0.095	-0.246	0.412
b5	292	0.007	0.091	-0.345	0.184

TABLE 5.1 Cont'd

Simple Statistics
For Estimated Arbitrage pricing Theory Risk Measures and
Traditional Accounting Risk Measures
(292 Companies, from the 1988-1991 Time Period)

Variable	N	Mean	Std Dev	Min	Max
CR	292	2.311	1.125	1.013	10.265
QR	292	1.296	0.8	0.391	6.639
WCTOV	292	7.702	12.079	0.585	181.939
COLPERD	292	57.609	23.121	17.293	262.617
INVTOV	292	5.146	5.209	0.007	65.423
DRTINWC	277	89.712	71	-43.33	396.46
INVTOCA	292	0.391	0.127	0.04	0.738
INVTOWC	292	1.041	2.018	0.091	33.697
TLTOTA	292	0.494	0.133	0.075	0.823
TLTOE	292	2.339	9.373	0.081	149.701
DTONFXAS	292	0.557	0.46	0.002	2.915
COVERAGE	292	13.099	30.774	0.041	418.06
GRSMRG	292	0.4	0.191	0.131	0.998
REOTA	292	0.076	0.05	0	0.375
REOE	292	0.16	0.094	0.001	0.689
TATOV	292	1.302	0.413	0.467	3.245
NFXASTOV	292	4.709	3.145	0.847	24.593
EXPTOREV	292	0.902	0.067	0.569	1
VEBIT	292	0.034	0.025	0.003	0.158
VSALES	292	0.189	0.114	0.021	0.732
NFAPEREM	291	64.11	100.087	2.961	773.514
REVENUE	292	6.872	1.655	2.452	10.997
PEREXCL	292	23.208	65.517	4.741	654.167
DPOUT	292	0.446	1.154	0	16.01
MRKTOBKV	292	2.189	1.39	0.557	14.068
CASH	292	0.271	0.974	0	11.593
PM	292	0.064	0.047	0	0.267

2. Predictive Correlation Analysis

Predictive correlation analysis among the estimated betas based on the 1989-1991 daily stock returns and the accounting risk measures of fiscal year 1988 provides additional evidence in support of our previous findings.

More specifically, examination of the correlation results reported in Table 5.2 reveals the following: For the first two estimated betas, we observe that sales (REVENUE) carry the highest correlation coefficient. Besides sales, most of the other accounting risk measures bear a strong correlation with the first and second beta. Namely, we see that liquidity ratios (CR, QR, WCTOV, COLPERD, DRTINWC, INVTOCA, and INVTOWC), leverage ratios (DTONFXAS), profitability/efficiency ratios (GRSMRG, REOTA, REOE, TATOV, NFXASTOV, and EXPTOREV), business risk measures (NFAPEREM), and the market power risk measure (MRKTOBKV), are highly correlated with the first two estimated APT risk measures.

Profitability (GRSMRG), and market power (MRKTOBKV) are the accounting risk measures bearing the highest correlation with the third APT risk measure. Other accounting risk measures bearing a lower correlation with the third beta are the liquidity ratios (INVTOV, INVTOCA, and CASH) and the net fixed assets per employee (NFAPEREM) measure of business risk.

Net fixed assets per employee (NFAPEREM) was the single most important variable, having the highest correlation, with the forth APT risk measure over the

TABLE 5.2

Correlation Analysis
Among and Arbitrage pricing Theory Risk Measures
and Traditional Accounting Risk Measures

(292 Companies, from the 1988-1991 Time Period)

	b_1	b_2	b_3	b_4	b_5
CR	-0.3807	0.27557	0.03867	-0.0391	0.19325
QR	-0.28072	0.21188	0.00653	-0.01543	0.16693
WCTOV	0.18955	-0.23936	0.00272	0.09621	0.00193
COLPERD	-0.15765	0.11418	-0.08451	-0.06239	0.05276
INVTOV	-0.03491	0.07888	0.14126	0.08311	-0.01234
DRTINWC	-0.28719	0.13071	-0.01615	-.0.2754	0.04316
INVTOCA	-0.13601	0.11103	0.12261	-0.01644	-0.01805
INVTOWC	0.12575	-0.16731	-0.05344	0.02519	0.02832
TLTOTA	0.11006	-0.07617	0.0165	0.1229	-0.10282
TLTOE	0.09028	-0.06522	-0.04284	0.04584	-0.06995
DTONFXAS	-0.26167	0.22953	0.01861	0.09814	0.06936
COVERAGE	-0.07817	-0.01527	-0.01934	-0.07049	0.1193
GRSMRG	0.20779	-0.26466	-0.22042	-0.09043	0.08758
REOTA	0.21427	-0.12434	-0.0608	-0.23878	0.13426
REOE	0.31415	-0.17976	-0.04233	-0.21809	0.0887
TATOV	-0.22434	0.18448	0.0437	0.00522	0.14906
NFXASTOV	-0.31746	0.22639	-0.07189	0.06322	0.16434
EXPTOREV	-0.30683	0.19632	0.09587	0.18803	-0.05214
VEBIT	0.08353	-0.07321	0.05848	-0.17314	-0.1009
VSALES	-0.00615	0.01019	-0.11664	-0.06929	-0.15665
NFAPEREM	0.14693	-294788	0.17225	0.29221	-0.05768
REVENUE	0.74109	-0.60009	-0.08322	-0.01387	-0.32192
PEREXCL	-0.13352	0.05156	0.00376	0.046	0.10199
DPOUT	-0.10229	0.04267	0.04315	0.01105	0.09297
MRKTOBKV	0.22307	-0.20981	-0.28156	-0.06881	0.1774
CASH	0.13162	-0.07164	-0.12673	-0.00898	0.04663
PM	0.28224	-0.18844	-0.08162	-0.21694	0.07737

1983-1986 period. The same variable continues to bear the highest correlation with the fourth beta over the 1988-1991 data period. In addition, profitability and efficiency ratios (REOTA and REOE) are equally strongly correlated with the fourth beta in this new sample. Other accounting variables bearing a weaker correlation with the fourth APT risk measure are the liability ratio (TLTOTA), efficiency ratio (EXPTOREV), and a business risk measure (VEBIT).

Sales seem to be the most important accounting risk measure regarding the fifth beta. The number of accounting variables bearing a strong correlation to the fifth APT risk measure increases dramatically when compared with our findings for the previous period. Liquidity ratios (CR, QR), liability ratios (COVERAGE), efficiency ratios (REOTA, TATOV, and NFXASTOV), and a business risk measure (VSALES), are the accounting risk measures associated with the fifth beta.

The last set of correlation analysis tests use cash flow based risk measures. The cash flow based definition of risk measures imposes a further constraint on our sample size. The sample used for the correlation analysis when cash flow based risk measures are included, contains 151 companies. Table 5.3 summarizes the simple statistics for the estimated betas and the cash flow based risk measures, and it reveals that there are no substantial differences between this period and our previous data set.

As you can see from table 5.5, correlation analysis among the estimated betas and the cash flow based risk measures reveals that efficiency and profitability ratios (CFOTA and CFOMRG) continue to be highly correlated with the first APT risk

TABLE 5.3

Simple Statistics of the
Arbitrage Pricing Theory Risk Measures and Cash Flow Based Risk Measures

151 Companies for the 1988-1991 period

Variable	N	Mean	Std Dev	Minimum	Maximum
b1	151	0.384	0.159	0.064	
b2	151	0.038	0.131	-0.303	0.269
b3	151	0.018	0.098	-0.444	0.329
b4	151	0.011	0.087	-0.176	0.384
b5	151	-0.003	0.091	-0.244	0.169
CFOTA	151	0.118	0.057	0.003	0.318
CFOD	151	1.372	2.336	0.015	13.598
CFOE	151	0.362	0.824	0.003	9.790
CFOMRG	151	0.106	0.065	0.002	0.361

TABLE 5.4

Correlation Analysis Among
Arbitrage Pricing Theory Risk Measures
and Cash Flow Based Risk Measures

151 Companies from the 1988-1991 period

	b_1	b_2	b_3	b_4	b_5
CFOTA	0.27081	-0.13875	-0.02947	-0.17441	-0.13756
CFOD	-0.08024	0.08132	-0.03675	-0.02392	0.10103
CFOE	0.08471	-0.09623	-0.01769	0.02884	-0.05309
CFOMRG	0.27426	-0.15656	-0.02746	-0.13888	-0.16631

TABLE 5.5

Correlation Analysis
Among Cash Flow Based Risk Measures

151 Companies from the 1988-1991 period

	CFOTA	CFOD	CFOE	CFOMRG
CFOTA	1	0.29504	0.13776	0.87681
CFOD	0.29504	1	0.05879	0.22704
CFOE	0.13776	0.05879	1	0.11523
CFOMRG	0.87681	0.22704	0.11523	1

measure. The correlation is moderate, with all of the remaining betas except the third one. Based on the findings of the correlation analysis we decided not to discuss the results of the regression analysis as they duplicate our earlier findings. Cash flow based risk measures do not add to the explanatory power of the estimated betas.

Overall, the predictive correlation analysis results indicate that accounting risk measures are consistently correlated with the first and second APT risk measure. Regarding the remaining estimated betas, the pattern of association that we attempt to establish is less obvious, as it changes with sample specification.

3. Regression Analysis

3.A. At the Individual Security Level.

For each beta, we choose the accounting risk measures best suited for use as explanatory variables, based upon stepwise regression procedures. Recall that the focal point in this procedure is the creation of parsimonious models that maintain explanatory power as close as possible to the saturation point.

The maximum attainable adjusted R^2 obtainable for each model, if multicollinearity was not a problem, is in the upper sixties for the first beta, and, low forties for the second one. These levels for maximum adjusted R^2 are similar to those found when we used the 1983-1986 data set. The maximum attainable explanatory power for the third, and especially the fourth, APT risk measures declines when we use the 1988-1991 set. Surprisingly the saturation point for the fifth beta is almost quadruple of what it was with earlier data, though still low at slightly more than 20 percent.

The following six variables are used in the regression model to explain the cross-section variation of the first beta (Table 5.6):

1. total liabilities to total assets (TLTOTA);
2. coverage ratio (COVERAGE);
3. expenses to revenue(EXPTOREV);
4. net fixed assets per employee (NFAPEREM);
5. sales (REVENUE); and,
6. market power (MRKTOBKV).

The regression model accounts for slightly more than 65 percent of the cross-sectional variation of the first APT risk measure. Of the six variables, total liabilities to total assets has the highest variance inflation factor measured to be 1.57. Hence multicollinearity does not seem to be an issue for this model. Examination of the signs reveals that the first beta captures the contrast between sales and market power versus financial structure, business risk and expenses. With the exception of the coverage ratio, the clustering of signs in these two groups seems to be consistent with the theoretically assumed association between these TARMs and risk in general.

Using three accounting risk measures in a regression model to explain the second beta, we can attain an adjusted coefficient of determination of 40 percent. The three ratios that we use are the profitability ratio (GRSMRG), a measure for

TABLE 5.6

Results of the Regression Analysis of Arbitrage Pricing Theory Risk Measures on Traditional Accounting Risk Measures

(292 Companies from the 1988-1991 Time Period)

b_1	Ind. Variables	Coefficient	Std. Error	p-value
	TLTOTA	-0.1910	0.0510	0.0000
	COVERAGE	-0.0010	0.0000	0.0000
	EXPTOREV	-0.5020	0.0940	0.0000
	NFAPEREM	0.0000	0.0000	0.0040
	REVENUE	0.0740	0.0040	0.0000
	MRKTOBKV	0.0180	0.0040	0.0000
	Adj.R^2=0.6514	VIF(TLTOTA)=1.57		
b_2	Ind. Variables	Coefficient	Std. Error	p-value
	GRSMRG	-0.135	0.032	0.0000
	VEBIT	-0.512	0.2370	0.0320
	REVENUE	-0.046	0.0040	0.0000
	Adj.R^2=0.4036	VIF(REVENUE)=1.02		
b_3	Ind. Variables	Coefficient	Std. Error	p-value
	TLTOE	-0.0070	0.0020	0.0010
	NFAPEREM	0.0000	0.0000	0.0000
	MRKTOBKV	-0.0250	0.0050	0.0000
	Adj.R^2=0.1744	VIF(TLTOE)=1.91		
b_4	Ind. Variables	Coefficient	Std. Error	p-value
	GRSMRG	-0.105	0.029	0.0000
	VEBIT	-0.784	0.2060	0.0000
	NFAPEREM	0.0000	0.0000	0.0000
	Adj.R^2=0.1575	VIF(NFAPEREM)=1.13		
b_5	Ind. Variables	Coefficient	Std. Error	p-value
	VSALES	-0.141	0.043	0.0010
	REVENUE	-0.019	0.0030	0.0000
	MRKTOBKV	0.015	0.0040	0.0000
	Adj.R^2=0.1731	VIF(MRKTOBKV)=1.02		

business risk (VEBIT), and sales (REVENUE). Multicollinearity is low for this model too, the highest variance inflation factor, corresponding to sales, is 1.02. As far as the signs are concerned, changes in each one of these accounting risk measures will have a similar influence on the second beta.

3.B. Regression Analysis at Portfolio Level.

Based on the new sample, we created fifty-eight portfolios for regression analysis. The variables chosen for each model, as well as the estimated regression models at portfolio level, appear in Table 5.7. The results of the regression analysis at portfolio level lend support to our previous findings.

More specifically, for the first beta, we find that it reflects the contrast between two opposing forces; Sales, profitability, and market power versus financial structure. As with the previous-period-results, the regression model demonstrates a significant explanatory power, as its adjusted coefficient of determination is 88.32 percent. Unfortunately, it was not feasible to find a model with a relatively low degree of multicollinearity; the variance inflation factor is 2.5 for total liabilities to total assets.

The second estimated beta continues to reflect the significant influence of sales. Also, we have two business risk measures (VEBIT and VSALES) entering the model with statistically significant coefficients. With the exception of variability of earnings (VEBIT), their estimated signs are compatible with their postulated

TABLE 5.7

Results of the Regression Analysis of
Arbitrage Pricing Theory Risk Measures on
Traditional Accounting Risk Measures

(58 Portfolios from the 1988-1991 Time Period)

b_1	Ind. Variables	Coefficient	Std. Error	p-value
	TLTOTA	-0.4200	0.1210	0.0010
	COVERAGE	-0.0020	0.0010	0.0020
	REOE	0.5910	0.1360	0.0000
	REVENUE	0.0720	0.0050	0.0000
	MRKTOBKV	0.0240	0.0110	0.0260
	Adj.R^2=0.8832	VIF(TLTOTA)=2.50		
b_2	Ind. Variables	Coefficient	Std. Error	p-value
	VEBIT	-2.6160	0.6830	0.0000
	VSALES	0.4140	0.1620	0.0140
	REVENUE	-0.0490	0.0040	0.0000
	Adj.R^2=0.6962	VIF(VEBIT)=1.50		
b_3	Ind. Variables	Coefficient	Std. Error	p-value
	INVTOCA	0.2030	0.1100	0.0710
	TLTOE	-0.0030	0.0010	0.0250
	PEREXCL	0.0000	0.0000	0.0520
	MRKTOBKV	-0.0180	0.0090	0.0610
	Adj.R^2=0.1999	VIF(MRKTOBKV)=1.09		
b_4	Ind. Variables	Coefficient	Std. Error	p-value
	VSALES	-0.1640	0.0940	0.0870
	REVENUE	-0.0200	0.0030	0.0000
	MRKTOBKV	0.0220	0.0080	0.0070
	VEBIT	-1.3470	0.4210	0.0020
	Adj.R^2=0.3098	VIF(GRSMRG)=1.40		
b_5	Ind. Variables	Coefficient	Std. Error	p-value
	VSALES	-0.1640	0.0940	0.0870
	REVENUE	-0.0200	0.0030	0.0000
	MRKTOBKV	0.0220	0.0080	0.0070
	Adj.R^2=0.4376	VIF(VSALES)=1.16		

theoretical ones. This may be taken as an indicator of an underlying pattern regarding the second beta that needs further examination. It should be noted that, we had a similar problem with the profitability measure (GRSMRG) in the portfolio regression analysis using the 1983-1986 data set. Again, because of their relatively small explanatory power, we refrain from discussing the regression results of the last three betas.

Analyses of the regression residuals obtainable both at the individual and the portfolio level appear in Tables 5.8 and 5.9 respectively. Recall that autocorrelation among the residuals may be attributed to measurement error in the explained variable, model misspecification, or missing explanatory variables. Creation of groups/portfolios was introduced as a potential solution to this problem. Therefore, comparison between the autocorrelations of residuals from regressions using individual securities versus group/portfolio data will be an indicator of the success of this solution to the autocorrelation problem. Examination of these two tables reveals that the degree of autocorrelation increases dramatically as we move towards betas of higher order. Regarding the residuals from the regression on the first estimated beta, we observe that they are significantly autocorrelated at the individual security level but not at the portfolio level. For the second beta, the autocorrelation coefficients are at a relatively high level; although analysis at the portfolio level leads to lower

TABLE 5.8

Autocorrelation of Residuals of the Regression of Arbitrage Pricing Theory Risk Measures on Traditional Accounting Risk Measures

292 Companies from the 1988-1991 period

lag	u_{b1}	u_{b2}	u_{b3}	u_{b4}	u_{b5}
1	0.345	0.578	0.786	0.853	0.787
2	0.308	0.574	0.698	0.791	0.777
3	0.387	0.573	0.673	0.779	0.733
4	0.328	0.562	0.635	0.785	0.706
5	0.391	0.529	0.596	0.758	0.689
6	0.399	0.567	0.577	0.740	0.669
7	0.232	0.548	0.565	0.704	0.644
8	0.348	0.478	0.508	0.683	0.634
9	0.326	0.477	0.521	0.655	0.627
10	0.373	0.519	0.484	0.658	0.616
11	0.383	0.511	0.496	0.649	0.609
12	0.310	0.484	0.497	0.610	0.591
13	0.281	0.461	0.480	0.604	0.581
14	0.269	0.428	0.476	0.611	0.568
15	0.311	0.468	0.470	0.600	0.551
16	0.370	0.402	0.457	0.590	0.558
17	0.259	0.396	0.460	0.573	0.560
18	0.316	0.411	0.463	0.565	0.581
19	0.272	0.389	0.448	0.556	0.554
20	0.307	0.410	0.427	0.543	0.546
Skewness	-0.246	-0.256	-2.264	0.288	-0.493
Kurtosis	0.897	-0.264	10.259	0.677	0.777
W:Normal	0.985	0.973	0.856	0.977	0.973
Pr<W	0.652	0.013	0.000	0.070	0.011

Note: u_{bi}'s are the lagged auto-correlations corresponding to the ranked by b_i residuals produced from the model used to explain the i^{th} APT risk measure. Analysis of the normality of the residuals is performed by examining the skewness, kurtosis as well as through the Kolmogorov's D test.

TABLE 5.9

Autocorrelation of Residuals of the Regression of Arbitrage Pricing Theory Risk Measures on Traditional Accounting Risk Measures

58 Portfolios from the 1983-1986 Period

lag	u_{b1}	u_{b2}	u_{b3}	u_{b4}	u_{b5}
1	0.080	0.337	0.523	0.505	0.451
2	0.052	0.170	0.469	0.458	0.255
3	0.097	0.149	0.441	0.524	0.374
4	-0.070	-0.016	0.420	0.607	0.328
5	-0.018	0.082	0.384	0.400	0.145
6	0.023	0.121	0.338	0.385	0.260
7	0.133	0.027	0.300	0.324	0.247
8	0.183	0.116	0.268	0.391	0.106
9	0.033	0.110	0.369	0.315	0.002
10	0.071	0.216	0.280	0.294	0.175
11	0.036	0.231	0.250	0.205	0.229
12	-0.023	0.018	0.212	0.257	0.083
13	-0.055	0.047	0.202	0.211	0.089
14	0.041	0.046	0.155	0.189	0.150
Skewness	-0.208	-0.341	-1.028	0.893	-0.539
Kurtosis	-0.353	0.543	4.684	2.706	0.980
W:Normal	0.976	0.969	0.934	0.944	0.955
Pr<W	0.527	0.283	0.005	0.018	0.067

Note: u_{bi}'s are the lagged auto-correlations corresponding to the ranked by b_i residuals produced from the model used to explain the i^{th} APT risk measure. Analysis of the normality of the residuals is performed by examining the skewness, kurtosis as well as through the Kolmogorov's D test.

degree of residual autocorrelation . Therefore measurement error is deduced to be the cause of the autocorrelation problem for the first, and possibly for the second, beta.

The residuals of higher order betas (third, fourth and fifth betas) have a higher autocorrelation both at individual and at portfolio levels. These findings provide some evidence that the measurement error may be only a partial cause for the autocorrelation problem. Model misspecification as well as missing explanatory variables may be the underlying causes; especially for the last three betas.

4. Comparison of the Regression Results.

Comparative regression results; across different sample specifications (individual securities and portfolio level), and over the two time periods (1983-1986 and 1988-1991), for each estimated beta, appear in Tables 5.10 through 5.19.

As far as the first estimated APT measure is concerned, examination of table 5.15 reveals that it is driven by two opposing forces. Financial structure, business risk and expenses versus revenues from sales and market power. Changes in sales and market power will change the first APT risk measure in the same direction. Their influence is statistically significant and consistent in both sample specifications and across time periods. On the other hand, changes in operating and financial leverage will move the first beta in the opposite direction.

Interestingly enough, the specifications of financial leverage that enter the regression models alternate with the time period. More specifically, during the first period (early eighties), total liabilities to equity is the influential financial leverage ratio, but total liabilities to total assets is the influential one during the second period. This finding requires further analysis particularly in light of the fact that 1987 - when market prices fell dramatically - is the cut off point between the two samples.

The explanatory power over the first beta attains relatively high values in portfolios in which the adjusted coefficient of determination ranges in the upper eighties. Analysis of the residuals for the first beta indicates a relatively low degree of autocorrelation which almost vanishes when we deal with portfolio level data. Based on this result, we argue that the observed autocorrelation may be attributable to measurement errors for the first beta.

For the second beta, a comparison of the summary results in Table 5.16 reveals that it is influenced by three major classes of explanatory variables. Namely, the influence of profitability measures, business risk, and revenues from sales. The last of these is the only one that maintains the same sign across different sample specification. Changes in both sales and variability of earnings will have similar influences on the second beta. Although this contradicts their postulated theoretical relations with risk, we argue that this is plausible since higher sales may be accompanied by higher volatility of operating earnings.[3] Approximately half of the variation of the second beta can be explained by the regression model using traditional accounting risk measures.

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[3]Theoretically they should have opposite effects on total risk. See chapter III.

Autocorrelation of the residuals of the second beta is more substantial than that of the first beta both at the individual as well as at portfolio level. Therefore, measurement errors may not be the only source that could account for autocorrelated residuals. Additional explanatory variables, beyond those used in our analysis, may be needed to improve the explanatory power of the regression model.

The contrasting effects of market power and capital intensiveness consistently appear in the regression model for the third beta. However, these accounting risk measures, by themselves, are inadequate in explaining the risk measure as their combined explanatory power is only moderate.

A similar story can be told for the fourth beta. The two opposing driving forces are capital intensiveness and sales. Again, the explanatory power is smaller during the second time period. This may be attributed to the fact that several influential liquidity ratios enter the picture only during the early eighties.

For the last three estimated betas, both the regression results and the analysis of the residuals indicate what we have stated earlier. We need either to incorporate other specifications of accounting risk measures or experiment with non-linear specifications of regression models.

TABLE 5.10
Comparison of Regression Results for b_1, 1988-1991 Period

Variable	Individual n=292	Portfolios n=58
CR		
QR		
WCTOV		
COLPERD		
INVTOV		
DRTINWC		
INVTOCA		
INVTOWC		
TLTOTA	(-)*	(-)*
TLTOE		
DTONFXAS		
COVERAGE	(-)*	(-)*
GRSMRG		
REOTA		
REOE		(+)*
TATOV		
NFXASTOV		
EXPTOREV	(-)*	
VEBIT		
VSALES		
NFAPEREM	(-)*	
REVENUE	(+)*	(+)*
PEREXCL		
DPOUT		
MRKTOBKV	(+)*	(+)*
CASH		
PM		
Adjusted R^2	0.6514	0.8832

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 5.11
Comparison of Regression Results for b_2, 1988-1991 Period

Variable	Individual n=292	Portfolios n=58
CR		
QR		
WCTOV		
COLPERD		
INVTOV		
DRTINWC		
INVTOCA		
INVTOWC		
TLTOTA		
TLTOE		
DTONFXAS		
COVERAGE		
GRSMRG	(-)*	
REOTA		
REOE		
TATOV		
NFXASTOV		
EXPTOREV		
VEBIT	(-)*	(-)*
VSALES		(+)*
NFAPEREM		
REVENUE	(-)*	(-)*
PEREXCL		
DPOUT		
MRKTOBKV		
CASH		
PM		
Adjusted R^2	0.4036	0.6962

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 5.12
Comparison of Regression Results for b_3, 1988-1991 Period

Variable	Individual n=292	Portfolios n=58
CR		
QR		
WCTOV		
COLPERD		
INVTOV		
DRTINWC		
INVTOCA		(+)*
INVTOWC		
TLTOTA		
TLTOE	(-)*	(-)*
DTONFXAS		
COVERAGE		
GRSMRG		
REOTA		
REOE		
TATOV		
NFXASTOV		
EXPTOREV		
VEBIT		
VSALES		
NFAPEREM	(+)*	
REVENUE		
PEREXCL		(+)*
DPOUT		
MRKTOBKV	(-)*	(-)*
CASH		
PM		
Adjusted R^2	0.1744	0.1999

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 5.13
Comparison of Regression Results for b_4, 1988-1991 Period

Variable	Individual n=292	Portfolios n=58
CR		
QR		
WCTOV		
COLPERD		
INVTOV		
DRTINWC		
INVTOCA		
INVTOWC		
TLTOTA		
TLTOE		
DTONFXAS		
COVERAGE		
GRSMRG	(-)*	
REOTA		
REOE		
TATOV		
NFXASTOV		
EXPTOREV		
VEBIT	(-)*	(-)*
VSALES		(-)**
NFAPEREM	(+)*	
REVENUE		(-)*
PEREXCL		
DPOUT		
MRKTOBKV		(+)*
CASH		
PM		
Adjusted R^2	0.1575	0.3098

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 5.14
Comparison of Regression Results for b_5, 1988-1991 Period

Variable	Individual n=292	Portfolios n=58
CR		
QR		
WCTOV		
COLPERD		
INVTOV		
DRTINWC		
INVTOCA		
INVTOWC		
TLTOTA		
TLTOE		
DTONFXAS		
COVERAGE		
GRSMRG		
REOTA		
REOE		
TATOV		
NFXASTOV		
EXPTOREV		
VEBIT		
VSALES	(-)*	(-)**
NFAPEREM		
REVENUE	(-)*	(-)*
PEREXCL		
DPOUT		
MRKTOBKV	(+)*	(+)*
CASH		
PM		
Adjusted R^2	0.1731	0.4376

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 5.15
Comparison of Regression Results for b_1, Across Periods

Variable	1983-1986 Period		1988-1991 Period	
	Individual n=373	Portfolios n=74	Individual n=292	Portfolios n=58
CR				
QR				
WCTOV				
COLPERD				
INVTOV				
DRTINWC				
INVTOCA				
INVTOWC				
TLTOTA			(-)*	(-)*
TLTOE	(-)*	(-)***		
DTONFXAS				
COVERAGE			(-)*	(-)*
GRSMRG				
REOTA				
REOE				(+)*
TATOV	(-)*	(-)*		
NFXASTOV				
EXPTOREV			(-)*	
VEBIT				
VSALES				
NFAPEREM	(-)*	(-)*	(-)*	
REVENUE	(+)*	(+)*	(+)*	(+)*
PEREXCL				
DPOUT				
MRKTOBKV	(+)*	(+)*	(+)*	(+)*
CASH				
PM				
Adjusted R^2	0.6431	0.8826	0.6514	0.8832

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 5.16
Comparison of Regression Results for b_2, Across Periods

Variable	1983-1986 Period		1988-1991 Period	
	Individual n=373	Portfolios n=74	Individual n=292	Portfolios n=58
CR				
QR				
WCTOV				
COLPERD				
INVTOV				
DRTINWC				
INVTOCA				
INVTOWC				
TLTOTA				
TLTOE				
DTONFXAS				
COVERAGE				
GRSMRG	(-)*	(+)*	(-)*	
REOTA				
REOE				
TATOV		(+)*		
NFXASTOV				
EXPTOREV				
VEBIT	(-)*		(-)*	(-)*
VSALES				(+)*
NFAPEREM				
REVENUE	(-)*	(-)*	(-)*	(-)*
PEREXCL				
DPOUT				
MRKTOBKV				
CASH				
PM				
Adjusted R^2	0.4930	0.7250	0.4036	0.6962

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 5.17
Comparison of Regression Results for b_3, Across Periods

Variable	1983-1986 Period		1988-1991 Period	
	Individual n=373	Portfolios n=74	Individual n=292	Portfolios n=58
CR				
QR				
WCTOV				
COLPERD	(-)*	(-)*		
INVTOV				
DRTINWC				
INVTOCA				(+)*
INVTOWC				
TLTOTA				
TLTOE			(-)*	(-)*
DTONFXAS				
COVERAGE				
GRSMRG				
REOTA	(+)*			
REOE				
TATOV				
NFXASTOV				
EXPTOREV		(-)*		
VEBIT	(-)*			
VSALES		(-)*		
NFAPEREM	(+)*		(+)*	
REVENUE				
PEREXCL				(+)*
DPOUT				
MRKTOBKV	(-)*	(-)*	(-)*	(-)*
CASH				
PM				
Adjusted R^2	0.2012	0.4162	0.1744	0.1999

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 5.18
Comparison of Regression Results for b_4, Across Periods

Variable	1983-1986 Period		1988-1991 Period	
	Individual n=373	Portfolios n=74	Individual n=292	Portfolios n=58
CR	(+)*			
QR				
WCTOV	(+)*			
COLPERD	(+)*	(+)*		
INVTOV				
DRTINWC				
INVTOCA				
INVTOWC				
TLTOTA				
TLTOE				
DTONFXAS				
COVERAGE				
GRSMRG			(-)*	
REOTA				
REOE				
TATOV	(+)*	(+)*		
NFXASTOV	(+)*			
EXPTOREV				
VEBIT			(-)*	(-)*
VSALES				(-)**
NFAPEREM	(+)*	(+)*	(+)*	
REVENUE		(-)*		(-)*
PEREXCL				
DPOUT				
MRKTOBKV				(+)*
CASH	(+)*			
PM				
Adjusted R^2	0.4796	0.6816	0.1575	0.3098

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

TABLE 5.19
Comparison of Regression Results for b_5, Across Periods

Variable	1983-1986 Period		1988-1991 Period	
	Individual n=373	Portfolios n=74	Individual n=292	Portfolios n=58
CR				
QR				
WCTOV				
COLPERD				
INVTOV				
DRTINWC				
INVTOCA				
INVTOWC		(+)*		
TLTOTA				
TLTOE				
DTONFXAS				
COVERAGE				
GRSMRG				
REOTA				
REOE				
TATOV				
NFXASTOV				
EXPTOREV				
VEBIT				
VSALES		(-)**	(-)*	(-)**
NFAPEREM	(+)**			
REVENUE	(-)*	(-)*	(-)*	(-)*
PEREXCL				
DPOUT				
MRKTOBKV			(+)*	(+)*
CASH				
PM				
Adjusted R^2	0.0510	0.3285	0.1731	0.4376

Note: The table reports the signs of the variables included in the regression models. Those significant at 5%, 10% and 20% level of significance are marked with one, two, and three stars respectively.

CHAPTER VI

SUMMARY AND CONCLUSIONS

In this dissertation we empirically tested the following question: 'Can we use traditional accounting risk measures from the current period to explain cross-sectional variations of the Arbitrage Pricing Theory (APT) risk measures in the next period?'

The empirical analysis was carried out using a sample of manufacturing companies from the Compustat data tapes available at the University of New Hampshire. The study covered two time periods: 1983-1986 and 1988-1991.

The dependent variables were the APT risk measures, derived from a principal factor analysis of daily stock returns. The set of independent variables was an extensive list of traditional accounting risk measures associated with a firm's operating and financial activities. The accounting risk measures used in this study represented the firm's liquidity, debt management, profitability and efficiency, business risk, and market value ratios, as well as the size of the company.

Relying on predictive correlation analysis and multiple regression analysis, an association was established between a firm's basic operating and financial characteristics, and the variations of the APT risk measures across a sample of individual companies as well as portfolios of manufacturing companies.

The statistical tests were run on both individual firm variables, as well as portfolios of firms. Several variables measuring various characteristics of firms were found to be significant in explaining each one of the APT risk measures. The following table summarizes the results which were significant in both periods in the analysis of individual companies or portfolios.

TABLE 6.1[1]

Significant Variables in Both Periods in the Analysis of Individual Companies or Portfolios

EXPLANATORY VARIABLES	First APT risk measure		Second APT risk measure		Third APT risk measure		Fourth APT risk measure		Fifth APT risk measure	
	I	P	I	P	I	P	I	P	I	P
REVENUE	✓	✓	✓	✓				✓	✓	✓
MRKTOBKV	✓	✓			✓	✓				
TLTOTA, TLTOE	✓	✓								
NFAPEREM	✓				✓		✓			
GRSMRG			✓							
VEBIT			✓							✓

As can be seen from the table, REVENUE, MRKTOBKV, TLTOTA or TLTOE, NFAPEREM, GRSMRG, and VEBIT, show up in this analysis. These variables respectively reflect, the size of firm (political power), monopolistic/market power, financial leverage, operating leverage, profitability, and business risk. These

[1] 'I' reflects the results corresponding to the analysis of individual companies and 'P' for the portfolios.

results are consistent with the findings of previous studies, e.g., Beaver, Kettler and Scholes (1970), Thompson (1976), McGowan, Etebari and Horrigan (1991).

Focusing on the results which were significant across both periods studied, from the analysis of the individual companies, the following remarks are offered. REVENUE and MRKTOBKV have the strongest influence, in the same direction, on the first APT risk measure. This result is not surprising given that these variables are both associated with political and monopolistic/market power of the firm.

The leverage variables (TLTOE or TLTOTA, and NFAPEREM) also impact on the first APT risk measure. However, changes in these variables counter balance the impact of political and market power variables. The use of more fixed inputs in a firm's production and/or use of more fixed obligations in its capital structure will amplify the variability of the company's earnings.

Size (REVENUE) and two business risk measures (GRSMRG, VEBIT) are the most significant variables in explaining the variations in the second APT risk measure. Size can be seen as a surrogate measure for other marginal variables.

Variations in the third APT risk measure can be attributed to the market power (MRKTOBKV) of the company and its operating leverage (NFAPEREM). The two of them have offsetting impact on the third APT risk measure. The impact of higher growth - reflected in MRKTOBKV - will be counter weighted by a higher degree of operating leverage. A measure of leverage (NFAPEREM) and size (REVENUE) respectively are the determining forces behind the cross sectional variations of the fourth and fifth APT risk measures.

From the portfolio level results it can be seen that size shows up in all but the third APT risk measure. This is not surprising, since size did not seem to play an important role on the third APT risk measure even at the individual security level. Market power, a significant explanatory variable for the first and third APT risk measures at the individual company level, appears also at the portfolio level. This is also true for financial leverage, a significant explanatory variable for the first APT risk measure. The rest of the explanatory variables - operating leverage, profit margin and business risk - do not show up at the portfolio level, presumably due to the aggregation of data. Business risk appears to be a significant explanatory variable for the fifth APT risk measure at portfolio level.

The concluding proposition of this dissertation can be summarized as follows: Traditional accounting variables, can be used to explain the APT risk measures across different sample specifications, as well as across different time periods. In this respect variables showing the greatest promise are measures of size, business risk, financial risk, and market power.

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