EMPIRICAL TESTS OF THE PREDICTIVE ABILITY OF ASSET PRICING MODELS AND OF STOCK MARKET OVERREACTION IN THE U.K.

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To my dearest grandma,
papa, mamma,
koko, saosao, and yao-chung
for their boundless love, support, and encouragement.

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SUMMARY

This thesis considers two major issues in the context of empirical research into the U K stock market: (i) what is the ability of five models (the naive market return, the market model, the CAPM, the APT, and the LAPT) for predicting the U K stock market price behaviour and (ii) does the U K stock market have long-term overreaction?

Chapter 2 reviews the literature of some financial topics. In Chapter 3, an asset pricing model called the Leveraged Asset Pricing Theory (LAPT) is developed. Unifying the Arbitrage Pricing Theory and the Modigliani and Miller Theory of capital structure, the model allows the changes in the underlying leverage variable of each company at time t-1 to have immediate impact on its beta estimated at time t. The predictive experimental procedures are designed, in Chapter 4, to examine the ability of the LAPT and other conventional models with different beta estimates to predict U K equity returns. Through the estimation procedures, the Trade-to-Trade and the Discount Weighted Estimation methods, based on Bayesian Forecasting, are used to avoid the problems of the nontrading effect and variation in parameters, respectively. The results, in Chapter 5, showed that when the year 1987 is added to the test, the predictive ability of both the APT and the LAPT becomes higher and the LAPT, which makes explicit the leverage factor in its structure, does even better job than the APT in market valuations around that period as more common factors are extracted for the LAPT.

Based on the controversial work of De Bondt and Thaler (1985), Chapter 6 examines the long-term overreaction behaviour of the U K stock market for the period 1965 to 1993. After relating the findings of this empirical study to the predictive ability of those benchmarks (the naive model, the market model, the CAPM, and the size-adjusted CAPM) used, the results indicate that the apparent evidence for overreaction depends upon the benchmark employed. The better the benchmark in terms of high predictive power and low statistical measurement error the less we are able to reject the null hypothesis of no overreaction. We find that we are unable to reject the hypothesis of U K stock market efficiency with respect to the Contrarian Investment Strategy of De Bondt and Thaler.

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ABBREVIATION

A.C.	Average Change
AC	Aggregated Coefficients method
ACAR	Averaged Cumulative Average Residual
ANOVA	Analysis Of Variance
APT	Arbitrage Pricing Theory
APT(n)	the Arbitrage Pricing Theory in which factor loadings (constant over time) are obtained from the factor analysis using all stocks that are continuously listed during the n-year period
AR	Average Residual return
CAPM	Capital Asset Pricing Model
CAR	Cumulative Average Residual
CCAPM	Consumption Capital Asset Pricing Model
CHMSW	Cohen, Hawiwini, Mayer, Schwartz, and Withcomb method
CML	Capital Market Line
CRISMA	Cumulative Volume, Relative Strength, Moving Average
CRR	Chen, Roll, and Ross
D/E	Debt to Equity Ratio
DJIA	Dow Jones Industrial Average
DWE	Discount Weighted Estimation
DWFEM	Discount Weighted Filtering Estimation Method
DWSEM	Discount Weighted Smoothing Estimation Method
EMH	Efficient Market Hypothesis
FCAPM	CAPM in where parameters are estimated by using DWFEM
FFCAPM	Fisher Friedman Capital Asset Pricing Model
FFJR	Fama, Fisher, Jensen, and Roll
FLM	Factor Loading Method
FMM	Market Model in where parameters are estimated by using DWFEM
FTA	Financial Times Actuaries all-share return index
GARCH	General Autoregressive Conditional Heteroscadasticity
GLS	General Least Squares
ICAPM	Intertemporal Capital Asset Pricing Model
LAPT	Leveraged Asset Pricing Theory
LAPT(n)	the Leveraged Asset Pricing Theory in which factor loadings (constant over time) are obtained from the factor analysis using all stocks that are continuously listed during the n-year period

LSE	Least Squares Error
LSPD	London Stock Price Database
ME	Mean Error
MM	Modigliani and Miller Theory
MR	Naive Market Return
MSE	Mean Square Error
MV	Market Capitalisation
MVM	Macroeconomic Variable Model
NYSE	New York Stock Exchange
OLS	Ordinary Least Squares
P/E	Price/Earnings
SAR	Semi-AutoRegression
SCAPM	CAPM in where parameters are estimated by using DWSEM
SMM	Market Model in where parameters are estimated by using DWSEM
SSE	Error Sum of Squares
SSTO	Total Sum of Squares
TSE	Toronto Stock Exchange
TT	Trade-to-Trade method

CHAPTER 1

INTRODUCTION

" *An anomaly is a rule or practice that is different from what is normal or usual, and which is therefore unsatisfactory* " quoted from the *COLLINS COBUILD ENGLISH LANGUAGE DICTIONARY*

Since the mid-1970s, there have been a number of economic "anomalies" discovered in stock returns For instance, abundant empirical studies documented that small capitalisation, low price/earning ratio, low Value Line timeliness rankings, or higher dividend yield stocks earn abnormal returns (the cross-sectional return effects) In addition, evidence also showed some calendar anomalies, such as the January, the turn-of-the-month, the weekend, the holiday, and the intraday effects which tend to occur at calendar turning points These peculiar patterns in stock returns are suggestive of market inefficiencies and have attracted a broad group of financial economists, searching for explanations Comparing the search for stock market imperfections to the snark hunt, O Maurice Joy (1987) applied the famous poem -- the hunting of the Snark composed by Lewis Carroll -- in his review article on efficient markets

> " The snark is a mysterious and rarely seen beast We are never told exactly what it is or what it looks like We are never sure if the elusive snark exists until the very end of the poem And even then, its existence is only dimly revealed through indirect evidence Nonetheless, the hunting expedition is launched with a colourful cast of characters Stock market inefficiencies are

also mysterious, rare, and dimly seen, and the hunting crew is equally colourful, ranging from Joe Granville to computerwielding academicians "

In academic activities, answering questions about the validity of theories or hypotheses requires hypothesis testing which refers to the process of trying to decide, on the basis of experimental evidence, the truth or falsity of such hypotheses Stock market efficiency per se, especially regarding event studies, is not testable, it must be tested jointly with some specific assumptions about the nature of a market equilibrium which proposes a simplified view of the real world However, the findings of persistent departures in stock returns are inconsistent with the joint hypothesis about market efficiency and the validity of the benchmark employed

Because of the joint hypothesis problem, this thesis is not to try to offer precise inferences about the degree of market efficiency As Fama (1991) stated, in his view, " the market efficiency literature should be judged on how it improves our ability to describe the time-series and cross-section behaviour of security returns ", this thesis is to test the long-term overreaction hypothesis using monthly data for U K stocks listed on the London Stock Exchange over the 1965-1993 and attempts to measure the relative forecasting performance of several equilibrium models in order to investigate how the results of testing overreaction differ between different equilibrium models This thesis generally consists of five major chapters, Chapter 3 to 7 inclusive, and covers two major issues in the context of empirical research into the U K stock market The two major issues are the predictive ability of various models, which will be dealt with in Chapter 3, 4, and 5, and the overreaction study for the U K stock market which will be analysed in Chapters 6 and 7 A detailed literature review related to the two empirical issues mentioned will be provided in each pertinent chapter A broad literature review of some topics, which I find more interesting, will be documented in Chapter 2 The organisation of this thesis is as follows

Chapter 2 is divided into three parts The first part introduces three conventional models -- the market model, the Capital Asset Pricing Model (CAPM), and the Arbitrage Pricing Theory (APT) -- in the capital markets It describes the development of these three risk-adjusted models incorporating key equations and the associated assumptions For each model, the existing empirical evidence relating to its validity will be described in order to gain more insights into the functioning of security markets and the pricing of individual assets The second part of Chapter 2 provides some issues concerning the efficient market hypothesis This part starts with some theoretical background on the efficient market hypothesis describing three models -- the fair-game model, the martingale, and the random walk -- unadjusted for the risk reflected in the time series behaviour of prices Thereafter it reviews the empirical literature on the efficient market hypothesis In the empirical literature of the efficient market hypothesis, a distinction is made between three levels of efficiency -- the weak-form, the semistrong-form, and the strong-form market efficiencies -- based on the amount of information involved

1 The market is efficient in the weak sense if the movements of current and future share prices are independent of the movements of past share prices

2 The market is efficient in the semi-strong sense if share prices respond instantaneously and in an unbiased manner to publicly available information

3. The market is efficient in the strong sense if share prices have impounded not only public but also private information

The final part of Chapter 2 documents some major anomalies recently cited in the financial literature. They are the firm size effect, the price-earnings ratio effect, the Value Line enigma, some calendar anomalies (such as the January effect, the monthly effect, the weekend effect, the holiday effect, and the intraday effect), and excess volatility. This part not only reviews the empirical evidence of these market anomalies, but also offers some explanations for each anomaly in an attempt to better understand more about the real financial markets.

According to the Capital Asset Pricing Model (CAPM), expected returns on each security are determined simply by the risk-free rate and the systematic risk -- beta. Inconsistencies between the statements of the theory and the empirical finding (for example, those finding of market anomalies), and difficulties in estimating returns from time series of realised stock return data led Merton (1980) to investigate three simple estimation models of equilibrium expected market returns. After his empirical study, Merton suggested three directions for further research. " First, because the realised return data provide 'noisy' estimates of expected return, it may be possible to improve the model estimates by using additional non-market data ", "A second direction is to employ a more sophisticated approach to the nonstationarity of the time series ", and " The third and most important direction is to develop accurate variance estimation models which take account of the errors in variance estimates. " Thus, Chapter 3 through Chapter 5, in this dissertation, follow Merton's three directions.

Chapter 3 starts with a brief review of the existing literature concerning beta estimations, such as historical and fundamental betas, in order to have some idea of their characteristics Then, an alternative model, the Leveraged Asset Pricing Theory (LAPT) which unifies the Arbitrage Pricing Theory and Modigliani and Miller Proposition II of capital structure, is derived Since the leverage factor (debt/equity ratio) is likely to be associated with relative risk changes, the purpose of constructing the LAPT is to try to bring this most important time-varying factor, leverage, more directly to bear in asset pricing and to show its effect on the systematic risk, beta, of its common stock.

In Chapter 4, an empirical comparative study is carried out in order to evaluate the quality of the newly-derived LAPT The predictive experimental procedures are designed to examine the ability of five operationalised models -- the naive market index, the market model, the CAPM, the APT, and the LAPT -- which have different beta estimates (or systematic risks) to predict U K equity returns Notably, the Trade-to-Trade and the Discounted Weighted Estimation methods are used to avoid the problems of the nontrading effect and variation in parameters, respectively, over the estimation procedures As will be mentioned in Chapter 4, nontrading is a serious problem especially in using U.K. data, and failure to adjust for nontrading will introduce several biases The Discount Weighted Estimation method will be chosen to estimate and to smooth changing parameters in this research This method produces recurrence relationships for the sequential updating of the regression parameters and of the variance, it not only allows the error term not to be homoskedastic but also need not to invert a correlation matrix (problems will arise when the independent variables are correlated) Subsequently, the sample data, and methodology used in this study of forecasting performance of the five models will be described in the last two sections of Chapter 4

The empirical results of comparing the predictive ability of the five models appear in Chapter 5 This chapter presents descriptive statistics, means, standard deviations of the various beta estimates, and correlation coefficients between them Thereafter it documents the mean errors (ME), mean square errors (MSE), and adjusted correlation coefficients to compare the predictive ability of the five models The conclusions of this empirical study are given at the end of the chapter

Based on the controversial work of De Bondt and Thaler (1985), the long-term overreaction behaviour in U.K. stock returns from 1965 to 1993 will be examined in Chapters 6 and 7. The objective of this research is to investigate jointly whether U.K. stock market returns revert (overreaction hypothesis) or the asset pricing models are misspecified Thus, the estimation procedures for each benchmark expected return, in this empirical study, are the same as described in Chapter 4 in order to draw some links between this empirical study and the previous one

Chapter 6 starts with a brief review of the existing evidence on stock market mean reversion and discusses stock market long-term overreaction behaviour in detail Then, preliminary results are obtained using the same data as in Chapters 4 and 5. Data sources and the De Bondt and Thaler's (1985) methodology for the U.K. stock market overreaction test is then described Also, the portfolio construction procedures and two statistical tests employed in this empirical research are specified near the end of the chapter

The empirical results for the tests of U K long-term overreaction hypothesis are reported in Chapter 7 With the empirically observed evidence, this chapter provides the link between long-term overreaction behaviour in U K stock market and the predictive ability of the operationalised models After investigating the relationships between the behaviour of the winner and the loser portfolios over the portfolio formation dates and the predictive ability of the benchmark used, some implications of these empirical results will be given at the end of chapter 7

Finally, Chapter 8 integrates the material contained in the earlier chapters A brief summary of the tests, results and discussion in the two empirical studies are offered, and this thesis is ended with some overall conclusions and suggestions for further research

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

The financial literature on stock price behaviour is extensive and mounts at such speed that a full review seems not possible. A broad overview of three main topics in financial research which most interested me will be provided in the following sections. Section 2.2. introduces three risk-adjusted models for capital markets -- the market model, the capital asset pricing model (CAPM), and the arbitrage pricing theory (APT). In section 2.3., the three hypothetical forms in which the efficient market hypothesis has generally been tested will be identified and briefly summarises a few of the many studies of market efficiency. Finally, a number of apparent anomalies (such as firm size effect, price-earning ratio effect, the Value Line enigma, some calendar anomalies, and excess volatility) and some possible explanations offered for each anomaly will be described in section 2.4.

2.2. Three Risk-adjusted Models

2.2.1. The Market Model

The objective of traditional investment analysis ought to be to maximise investors' expected utilities, but in practice may be influenced heavily by the investors' intuitions. Modern investment theories are based on expected utilities and quantitative risks, in order not to rely on subjectivity or the bias of the investors' personal misjudgement In 1950-51, Dr Harry M Markowitz[1] pioneered an epoch-making modern portfolio theory He laid down a cornerstone of modern portfolio theory by measuring risk in terms of a matrix of covariances to compute the variance of a portfolio of securities The problem of computing portfolio variance is made more complex, however, by the number of estimates required Suppose, for example, there are N stocks in the investor's universe, to employ portfolio analysis, he or she needs estimates of N expected returns, N expected variances, and N(N-1)/2 covariances The huge number of covariances seems unlikely to be estimated as the number of securities becomes large This problem has motivated the search for the development of simpler models to describe and predict the correlation structure between securities

An alternative model, the "single-index model" which was first suggested by Markowitz and later developed by Sharpe (1963) relates the returns on the various securities through common relationships with an index The contribution made by Sharpe was the reduction in the number of estimates required from N(N+3)/2 in the Markowitz-model formulation to 3N+2 (an estimate of both the expected return and variance for the market, and N estimates of expected return, the variance of the return, and Beta for N stocks, respectively) in the single-index formulation This most popular model is usually referred to as the "market model" The relationship between the security return and the market index is as

$$R_i = \alpha_i + \beta_i R_m + \varepsilon_i \tag{2 1}$$

where α_i is the component of security i 's return that is independent of the market's performance (a random variable),

[1] For a more detailed description, see H M Markowitz "Portfolio Selection Efficient Diversification of Investments" (Cowles Foundation Monograph No 16 [New York John Wiley & Sons, 1959])

R_m is the market return (a random variable),

β_i is a sensitive measure of the expected change in R_i given a change in R_m

Unlike the market portfolio in the CAPM (described subsequently), we do not have to be too careful about what we mean by the "market" since all broadly based indexes or portfolios are highly covariant

A study by Cohen and Pogue (1967) empirically evaluated the performances of the market model and two multi-index models -- the covariance form in which the return on each security is assumed to be linearly related to the return on the index of the industry to which it belongs and the diagonal form which has the same basic structure as the covariance form, with the additional assumption that returns on each industry index are linearly related to returns on an overall market index The results showed that the market model not only led to lower expected risks but also was less costly and much simpler to use than the more elaborate multi-index models Recently, Chang (1991) compared three empirical models of stock return generation (1) a market model, (2) a multifactor macroeconomic model, and (3) a combined macro-market model for investigating the intertemporal stability of the model parameters and of the ability of the models to predict He found that the market model outperformed the multifactor macroeconomic model but had similar results with the combined macro-market model This result compares with Elton and Gruber's (1973) conclusion that although the multi-index model did a better job of explaining the historical correlation matrix, it did not do a better job of predicting than the market model

2.2.2. The Capital Asset Pricing Model (CAPM)

Tobin (1958) showed that, under certain conditions such as risk averse investors and liquidity preference, Markowitz's model implies that the process of investment choice can be broken down into stages at different levels of aggregation. Later, Sharpe (1964) suggested two stages: (1) the choice of a unique optimum combination of risky assets, and (2) a separate choice concerning the allocation of funds between such a combination and a single riskless asset. Almost about the same time, Sharpe (1964), Lintner (1965a),(1965b), and Mossin (1966) developed independently an equilibrium asset pricing theory and led the study of return-risk relationships into a new era by introducing the Capital Market Line (CML) and the separation theorem. The separation theorem states that the optimum portfolio of risky assets is determined by only two portfolios, the market portfolio and the riskless asset, if it exists and is unaffected by the investor's risk aversion. The model they developed is often referred to as the Sharpe-Lintner-Mossin standard CAPM (Capital Asset Pricing Model) which is an extension of the Markowitz-Tobin portfolio model. The ex-ante CAPM form is as follows:

$$E[R_i] = R_f + \beta_i\left[E(R_m) - R_f\right] \qquad (2.2)$$

where $\beta_i = \dfrac{Cov(R_i, R_m)}{Var(R_m)}$ is the quantity of risk,

R_f is the risk-free rate.

This equilibrium model is derived under a list of assumptions.

(1) There exists a risk-free asset such that investors may borrow or lend without limit at the risk-free rate of interest.

(2) Investors are risk-averse individuals who have homogeneous beliefs about asset returns that have a joint normal distribution.

(3) There are no market imperfections.

(4) All assets are marketable and perfectly dividable.

(5) Information is costless and simultaneously available to all investors.

The elegantly constructed CAPM, derived under several stringent assumptions, has stimulated great interest in exploring its ability to describe reality and in developing other equilibrium models based on more realistic assumptions. Black (1972) replaced the risk free asset with a portfolio that has the zero covariance with the market portfolio and constructed the second most widely used general equilibrium model -- the zero beta version of the CAPM. Brennan (1971) demonstrated a pricing model which allows borrowing and lending rates to differ. Brennan (1970) developed an after-tax asset pricing model which allows differential tax rates on capital gains and dividends, based upon the assumption that distributions of returns are lognormal. Merton (1973) developed a version of the Intertemporal Capital Asset Pricing Model (ICAPM). Further, Breeden (1979) attempted to simplify Merton's model by evaluating assets in terms of consumption rather than expected values[2] and this model is usually referred to as the Consumption Capital Asset Pricing Model (CCAPM). Bollerslev, Engle, and Wooldridge (1988) employed the GARCH method to

[2]U.S. evidence: Breeden, Gibbons, and Litzenberger (1989)
German evidence: Sauer and Murphy (1992)

incorporate the conditional heteroskedasticity in stock returns. Chen and Boness (1975) assumed that investors have homogeneous expectations over the probability distribution of the expected rate of inflation and developed the Chen-Boness CAPM under uncertain inflation. While Burnie (1986) incorporated the effect of the Friedman hypothesis[3] through the Fisher hypothesis[4] on the CAPM under uncertain inflation and derived the Fisher Friedman CAPM (FFCAPM).

Black, Jensen, and Scholes (1972) were the first to use an instrumental variable approach which employs the beta for each security in the previous time period to reduce the bias in estimating beta, they found that the empirical model which expresses the relationship between excess return and risk is linear with positive slope, but the intercept term is significantly different from zero. This evidence is powerful in support of the constrained borrowing version -- the zero-beta CAPM[5]. There should be no surprise that the empirical tests are more consistent with the constrained borrowing version of the model, because the predictions of the zero-beta CAPM are less precise than those of the traditional version of the model (see equation 3.2). Using the same procedure as Black, Jensen, and Scholes's to estimate betas, Fama and MacBeth (1973) tested for linearity by adding two terms to the linear model involving the square of beta and unsystematic risk (residual variance) in explaining returns. They still found a significantly positive intercept term, but no significant relationships between expected

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[3] The Friedman hypothesis (1977) suggests that imperfections in the system can delay a quick adjustment to inflation and that dislocations do occur from the optimum adjustment path.

[4] The development of the FFCAPM assumes a Fisher effect, $R_{ja} = R_j + R_a$, the nominal inflation rate of return R_{ja} equals the real rate of return R_j plus the nominal inflation rate R_a, which states that asset returns should fully adjust upward (downward) for inflation (deflation).

[5] Faff (1991) employed the multivariate approach with a value weighted market index to test the zero-beta capital asset pricing model by using Australian data for the period 1974 to 1987. The results were supportive of the zero-beta CAPM.

return and beta squared term, and between expected return and unsystematic risk The results of Fama and MacBeth are opposite to those of Lintner (1965a), Douglas (1968), and Levy (1978) regarding the importance of residual risk The divergence of results can be explained by the opinion of Miller and Scholes (1972) that if beta has large sampling error, then residual risk served as a proxy for true beta After controlling for different levels of beta, the results of Foster (1978) are consistent with those of Fama and MacBeth that there is no significant relationship between residual variance and returns

The Sharpe-Lintner-Mossin constructed CAPM is basically an ex-ante form in which all variables are expressed in terms of expected future values The mean-variance efficient market portfolio under the CAPM construction theoretically contains all risky assets (marketable and nonmarketable, e g stocks, bonds, options, coins, property, human capital, etc) Unfortunately, expectations for the true market portfolio are impossible to observe Thus Roll (1977) argued that the CAPM is not testable, and tests of the CAPM are simply tests of whether the portfolio chosen as a proxy for the market (e g stock market index) is ex-post mean-variant efficient or not

If the theoretical CAPM is untestable, then tests of the Sharpe-Lintner-Mossin CAPM in empirical research become tests of altered versions of the CAPM where the market portfolio is replaced by reasonable market proxies and the true beta is replaced by a beta estimate from some benchmark period which is assumed to be relevant for the event period Although there is no theoretical reason to suppose that the altered version of the CAPM will hold, empirical researchers are still interested in testing it in order to see if it helps us understand share price behaviour Fama and French (1992) recently examined a number of variables -- market beta, firm size, book-to-market equity, leverage, and E/P ratios -- to see which variable has the greatest explanatory power in explaining the average returns on the NYSE, AMEX, and NASDAQ stocks for 1963-1990, they found that book-to-market equity had great explanatory power, and after controlling for firm size, the relation between market beta and average return was not significant

There are innumerable empirical studies showed that factors other than beta are successful in explaining the security returns These phenomena contradicting the altered CAPM are called anomalies and will be discussed in section 2 4

2.2.3. The Arbitrage Pricing Theory (APT)

About the same time as Roll's critique, Ross (1976),(1977) developed and proposed another equilibrium multi-factor model -- the Arbitrage Pricing Theory (APT) -- which is based on what economists call the law of one price[6], that means there are no arbitrage opportunities (in the limit) in an equilibrium market

$$R_i = \alpha_i + \beta_{1i} F_1 + \cdots\cdots + \beta_{(J-1)i} F_{(J-1)} + \varepsilon_i \qquad (2.3)$$

where F_j's are the factors which impact the return on firm i,

α_i is the expected return for firm i if all the factors F_j's have values of zero,

β_{ji} is the sensitivity of firm i ' s return to the factor j,

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[6] The law of one price is the condition that identical goods at different places must sell at the same dollar price

and ε_i is a random zero mean noise term for firm i

The APT is more general than a CAPM-type model It allows the equilibrium asset returns to be linearly related to a set of indices, not just one (e g market portfolio), it makes no assumptions about the empirical distribution of asset returns and no strong assumption about investors' utility functions, and it is easily extended to a multiperiod framework In the empirical studies, it is possible that more than one index explains the covariance between asset returns, and the CAPM still holds if indices can be represented by the market portfolio, because both models assume a linear returns generating process and are equilibrium forms Although the APT is more robust than the CAPM, there are still some assumptions constrained for the construction of the APT, therefore, it has been simplified and extended by Huberman (1982), Chamberlin and Rothschild (1983), Dybvig (1983), Ingersoll (1984), Grinblatt and Titman (1983), and Koutmos and Theodossiou (1993)

In most empirical research testing the APT, factors are determined either by derived factors produced by multivariate statistical techniques or by macroeconomic variables defined as innovations in a set of macrovariables Roll and Ross (1980) first used the two-stage procedure with the maximum likelihood factor analysis[7] to test the APT and found that at least three and probably four factors are significant, Brown and Weinstein (1983) applied a bilinear paradigm introduced by Kruskal (1978) to obtain joint estimates of factor loadings and factor scores, i e risks and risk premia, and their

[7] Futher examples of using the two-stage procedure with the maximum likelihood factor analysis are Gehr (1975), Oldfield and Rogalski (1981), Reinganum (1981), Chen (1983), and Cho and Taylor (1987)

results are consistent with the three factor APT. According to the results of Kryzanowski and To (1983), Cho, Elton, and Gruber (1984), Dhrymes, Friend, and Gultekin (1984), and Dhrymes, Friend, Gultekin, and Gultekin (1985), it can be summarised that the number of factors differs among different sample sizes and among different time periods analysed.

The U.K. studies of the APT employing the maximum likelihood factor analysis include Diacogiannis (1986), and Abeysekera and Mahajam (1987). Diacogiannis tested the validity and testability of the APT by using the U.K. securities listed on the London Stock Exchange from 1 November 1956 to 31 December 1981, and concluded that an unambiguous test of the APT for the LSE cannot be obtained by employing factor analysis. Abeysekera and Mahajam (1987) allowed each portfolio, consisting of 40 randomly selected securities, to be analysed separately for up to eight factors employing the General Least Square (GLS) regression procedure to estimate the intercept and risk premia. Based on both the Chi-square test and the t-test, the results showed that the risk free rates equal to the estimated intercept terms of the models cannot be rejected, and also did not reject the second hypothesis that the risk premia are insignificantly different from zero.

Other statistical techniques, i.e. principal components analysis, canonical correlation analysis, semiautoregression approach (SAR)[8], etc., have been utilised to extract factors of the APT, but the results of testing the APT are still mixed at best. All

[8] See Trzcinka (1986), Brown (1989), and Shukla and Trzcinka (1990) for principal components analysis. See Christofi, Christofi, and Philippatos (1993), and McGowan and Dobson (1993) for canonical correlation analysis. See Mei (1993) for semiautoregression approach.

of the tests are joint tests of the APT and the particular statistical methodology used to test it

Chen, Roll, and Ross (1986) employed another empirical method[9] to test the APT, prespecifying factors which are five specific macroeconomic factors, namely, industrial production, changes in the risk premium for bonds, the term structure of interest rates and both expected and unexpected inflation Using U S data for the period 1958 to 1984, they grouped stocks into 20 size sorted portfolios prior to estimation, and found that these macroeconomic variables are significant explanatory influences on pricing Surprisingly, the market portfolio had an insignificant influence on pricing when it was introduced as an additional variable

Poon and Taylor (1991) carried out a similar set of tests (but adjusted data for autocorrelations) using U K data from the beginning of January 1965 to the end of December 1984 to see if the findings reported by Chen, Roll, and Ross (CRR) for the U S can be extended to the U K market Their results showed that variables similar to those of CRR do not affect U K share prices in the way they affect U S share prices Another U K study by Clare and Thomas (1994) tested the robustness of the results of testing the macrovariables APT to different portfolio ordering techniques Using market beta sorted portfolios, they found that a number of macroeconomic variables, oil prices, two measures of corporate default risk, the retail price index, U K private

[9] U S evidence Chan, Chen, and Hsieh (1985), Shanken and Weinstein (1985),(1987), Cho and Pak (1986), and Burmeister, Wall, and Hamilton (1986)
Japan evidence Hamao (1988)
Australian evidence: Faff (1988)
Spain evidence Martinez and Rubio (1989)
U K evidence Peel and Pope (1985),(1988), Saunders (1987), and Kamarotou and O'Hanlon (1989)

sector bank lending, the current account balance, and the redemption yield on an index of U K corporate debentures and loans, had been priced But only two variables, one of the measures of market risk and the retail price index, appeared to have been priced when portfolios were sorted by market value As Poon and Taylor suggested "It could be that other macroeconomic factors are at work, or the methodology in CRR is inadequate for detecting such pricing relationships, or possibly both explanations apply"

Although specifying the APT factors as macrovariables may provide a direct link between microeconomic policies of corporations and macroeconomic events, the selected variables are correlated[10], and the procedures for selecting variables are informal due to the lack of formal theoretical guidance However, a study by Chen and Jorden (1993) compared the performance of the factor loading model (FLM) and the macroeconomic variable model (MVM), and the results are in favour of the MVM when the two models were tested against a holdout sample or against a test period

2.3. The Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) is defined by many researchers from different perspectives In a macroeconomic sense, Henfrey, Albrecht, and Richards (1977) gave a broader definition of efficiency that share prices are established at "economically" correct levels which optimise capital allocation within the economy as a

[10] McElory and Burmeister (1988) utilised the nonlinear seemingly unrelated regression (SUR) methods (without the assumption of normally distributed errors) instead of Fama and MacBeth two-stage regression method

whole rather than simply within the quoted sector. In a narrower view, Fama (1970) described the efficient market as security prices that "fully reflect" all available information. Later Fama (1976) proposed that an efficient capital market in which the prices of securities observed at any time are based on "correct" evaluation of all relevant information available at that time. Beaver (1981) defined an efficient market based on an information distribution in which security prices that exist with respect to a specific information set are the same as the prices that would exist if everyone has that information set. In fact, no matter which definition is used, empirical tests of market efficiency require an expected return model and therefore become joint tests of market efficiency and the pricing model.

The development of the efficient market theory, unlike other theories, succeeded the empirical research. Thus, owing to the lack of a theoretical foundation, some of the early empirical evidence concerning market efficiency seemed vague and confusing. It was not until the paper of Fama in 1970 that the efficient market theory and hypotheses were generally defined. Three of the theoretical models found in the literature are unadjusted for risk of the time series behaviour: (1) the fair-game model, (2) the martingale or submartingale, and (3) the random walk.

(1) The mathematical expression of fair-game model:

Let

$$r_{i,t+1} = \frac{P_{i,t+1} - P_{i,t}}{P_{i,t}} \quad \text{and} \quad E\left(r_{i,t+1} \middle| D_t\right) = \frac{E\left(P_{i,t+1} \middle| D_t\right) - P_{i,t}}{P_{i,t}} ,$$

then $\quad E(\varepsilon_{i,t+1}) = E[r_{i,t+1} - E(r_{i,t+1}|D_t)] = 0$, where $P_{i,t+1}$ = the actual price of security i at time t+1,

$E(P_{i,t+1}|D_t)$ = the predicted price of security i at time t+1 given the current information set, D_t, which is assumed to be relevant for determining security prices at time t

$r_{i,t+1}$ = one period return at time t+1,

and $\varepsilon_{i,t+1}$ = the difference between actual and predicted returns

A fair game means that, on average, the expected return on an asset is unbiased and equals its actual return based on large samples, but the covariances between successive returns may be nonzero

(2) The mathematical expression of the submartingale and the martingale are, respectively:

$$E(r_{i,t+1}|D_t) = \frac{E(P_{i,t+1}|D_t) - P_{i,t}}{P_{i,t}} > 0 \qquad \text{and} \qquad E(r_{i,t+1}|D_t) = \frac{E(P_{i,t+1}|D_t) - P_{i,t}}{P_{i,t}} = 0$$

A submartingale says that expected returns are positive, that is the price at time t+1 is expected to be greater than price at time t. A martingale says that expected returns are equal to zero, implying that price at time t+1 is expected to be equal to price at time t

Both submartingale and martingale models are fair games, constraining expected returns to be, respectively, greater than or equal to zero Samuelson (1965), and Mandelbrot (1966) based on analyses of futures contracts in commodity markets developed the link between capital market efficiency and martingales They elucidated relationships between these "fair game" expected return models and the random walk model

(3) The random walk model, $f(r_{i,t+1}|D_t) = f(r_{i,t+1})$, is a restricted version of the fair game model requiring that all the parameters of the returns distribution, e g mean, variance, skewness, and kurtosis, to be the same regardless of the information and also that returns are independently and identically distributed Thus, the random walk strictly requires serial covariances between returns for any lag to be zero The most important distinction between the martingales and the random walk is that nonzero correlation in successively conditional variances of returns is allowed in martingales but not in random walks

The earliest literature of the random walk hypothesis can be traced back to Bachelier (1900) who concluded that the price of a commodity today is the best estimate of its price in the future, and prices tend to follow a random walk in such a competitive market It was not until 1953 that Kendall examined British industrial share prices and other economic time series and found that weekly changes behaved like a random walk But Fama (1965) subsequently examined the serial correlations of one-day changes in the natural logarithm of price for the Dow Jones Industrials, and showed that the serial correlations are significantly different from zero Recent empirical studies tried to devise different methods to test the random walk hypothesis

For example, Durlauf (1991) proposed that we can use spectral distribution[11] estimates to test whether a return series is a martingale McQueen (1992) used generalised least-squares (GLS) randomisation tests instead of the ordinary least-squares (OLS) tests to test NYSE stock returns on the 1926 to 1987 period, and the random walk cannot be rejected for value- or equally- weighted real returns MacDonald and Power (1993) investigated a disaggregate U K weekly stock return data by using variance ratio and rescaled range tests over the period January 1982 to June 1990 and concluded that U K share prices follow a random walk, and are unpredictable This conclusion is contrary to Lo and Mackinlay's (1988)[12] evidence for aggregate index data and contrary also to MacDonald and Power's (1992) findings for size-based portfolios Using a parametric bootstrap test which is able to account for some forms of heteroskedasticity, Brock, Lakonishok, and LeBaron (1992) concluded that trading profits[13] are not consistent with a random walk Kim, Nelson, and Startz (1991) showed that the mean reversion of stock returns had been overstated because of assumptions of a normal distribution and was a pre-war phenomenon only Nonetheless, McQueen and Thorley (1991) used a finite-state Markov chain to examine all NYSE stock returns for the post-war period, from 1947 to 1987, and rejected the random walk hypothesis for the post war period

Fama (1970) categorised market efficiency into three different levels -- the weak-form, the semi-strong form, and strong form market efficiencies, based on the

[11] Earlier work by Granger and Morgenstern (1963) used spectral analysis. Spectral analysis is a statistical method of testing for cyclical behaviour in a time series Under the null hypothesis, the spectral distribution function is shaped as a straight line

[12] In their recent paper. Lo and MacKinlay (1990) showed that nontrading effect is responsible for the rejections of the random walk hypothesis

[13] The returns conditional on buy (or sell) signals from the actual Dow Jones data are compared to returns from a simulated random walk series

type of information involved in order to have more clear-cut division among the innumerable empirical tests. Later, in his second review of efficient capital market, Fama (1991) changed the name of each category respectively to return predictability tests (including the anomalies and price volatility), event studies, and private information tests.

2.3.1. Weak-Form Market Efficiency

The market is efficient in the weak sense if the movements of current and future share prices are independent of the movements of past share prices, that means share prices have no memory. Current share prices have fully reflected all available information embodied in the past share prices and no one can gain excess returns by using any trading rules based on past price and return series alone.

In his earlier article, Alexander (1961) found that his filter rules[14] of all different sizes from 0.5 percent to 50 percent and for all different time periods from 1897 to 1959 produced substantial profits compared with those of the simple buy-and-hold strategy. However, after taking discontinuities in the price series into account, Alexander (1964) subsequently found that the filter results tend to support the independence assumption of the random walk. Fama and Blume (1966) focusing on all individual stocks in the Dow-Jones 30 over the period 1956-1962 and Corrado and Lee (1992) examining a sample of 120 Dow Jones and S&P 100 stock for the period 1963-1989, both found that filter rules could not generate sufficient profits to cover

[14] Filter rule strategy is to purchase the stock when it rises by X% from the previous low and hold it until it decline by Y% from the subsequent high. At this point, sell the stock short or hold cash.

transaction costs Jennergren and Korsvold (1975) examined some Norwegian and Swedish stocks with relatively high correlations and concluded that when taxes and transaction costs were considered, the filter rules were unprofitable Dryden (1970), however, following Fama and Blume's (1966) methodology found that a filter rule applied to three indices of U K share prices indicated potential profits Further, in recent papers, Sweeney (1988) reexamining some of the results from Fama and Blume (1966) and simply testing the individual stocks that looked most promising in the Fama and Blume's work for the later period 1970-1982, found that these promising stocks seem to persist in giving superior filter results The purpose of employing filter rules to test weak-form market efficiency is to examine serial correlations or cyclical behaviour in a share price or return series, e g mean reversion in stock returns, which is one of the subjects of this thesis and will be explained in detail in Chapter 6

Another popular technical rule for selecting stocks is the relative strength method which is based on the ratio of a stock's current price to an average of recent prices Levy (1967) suggested investing in securities that had appreciated the most in the recent past and found that this rule would yield abnormal portfolio returns When Jensen and Bennington (1970) tested Levy's procedure on other sets of data, no significant abnormal return was found after considering transaction costs

In recent articles, Pruitt and White (1988),(1989) demonstrated an unusual finding employing a multi-component technical system known as the CRISMA (Cumulative Volume, Relative Strength, Moving Average) trading system to U S stock market over the years from 1976 to 1985, stock and options traders would have earned significantly abnormal returns, even after adjusting for problems of trade timing, risk, and transaction costs. Furthermore, Pruitt, Maurice, Tse, and White (1992) examined the predictive ability of CRISMA system over the updated period from 1986 to 1990 and verified the persistence.

We can conclude that while most evidence has not permitted rejection of the weak-form hypothesis, there is some more recent anomalous evidence that remains unexplained.

2.3.2. Semi-Strong Market Efficiency

The market is efficient in the semi-strong sense if share prices respond instantaneously and in an unbiased manner to publicly available information, that means current share prices have fully reflected public news about the underlying companies, and no one can gain excess returns by using any trading rules based on the news.

It is possible to distinguish two types of tests of semi-strong efficiency, one using macro data and the other based on micro data such as company specific announcements. For example, Groenewold and Kang (1993) used three macroeconomic variables, monetary growth rate[15], inflation rate, and the growth rate of government expenditure to examine the joint explanatory power in regressions for Australian share returns and could not reject the semi-strong EMH. These results are

[15] Futher examples are Sprinkel (1964), Homa and Jaffee (1971), Hamburger and Kochin (1972), Malkiel and Quandt (1972), Cooper (1974), Pesando (1974), Rozeff (1974), Tanner and Trapani (1977), and Sorensen (1982).

contrary to those of Sharpe (1983), Hogan, Sharpe and Volker (1982), and Saunders and Tress (1981) Darrat (1988) investigated the relationship between aggregate quarterly stock returns and a number of important macro variables in the Canadian case and found that besides the monetary variable, the short-term interest rate[16], the inflation rate and lagged fiscal policy effects exhibited statistical significance in explaining stock returns

The study by Fama, Fisher, Jensen, and Roll (FFJR) (1969) was the seminal test of the semi-strong form of the efficient market hypothesis They found that shares of stock splitting firms earned abnormal returns for 29 months prior to the announcement of the split but virtually none after the announcement FFJR argued that it might be that these observed abnormal returns were attributable to other more fundamental changes than stock splits such as dividend announcements A more recent study by Grinblatt, Masulis, and Titman (1984) used daily return data and observed the behaviour of shareholder returns around the stock split and stock dividend announcement dates as well as around the ex-dividend dates and split dates[17] They found statistically significant announcement returns for this sample of "pure" stock splits, for the sample of stock dividends and, surprisingly, significant returns on the ex-dates The latter can be explained by the model developed by Brennan and Hughes (1991) Brennan and Hughes explored the dependence of the brokerage commission rate on share price, and concluded that there is an inverse relationship between the number of analysts making a forecast about a firm and its share price and an increase in the amount of information generated by analysts after the ex-date That means, to trade

[16] Waud (1970) tested the simi-strong efficiency also based on the short-term interest rate
[17] Charest (1978a)

in low priced shares is more costly, therefore, investors will be compensated by gaining extra return for the transaction costs[18]

Using the same sample as that in Grinblatt, Masulis, and Titman (1984), Ball and Torous (1988) considered the problem of uncertainty of an event's calendar date by applying the maximum-likelihood method to investigate the response of common stock returns to announcements of stock splits and stock dividends The results confirmed Grinblatt, Masulis, and Titman's conclusions which have been mentioned in last paragraph The evidence about dividends in recent empirical studies seems inconclusive, Watts (1973) using monthly data argued that the information content of dividends can only be trivial because the returns from the dividend information would not exceed transactions costs Further, Charest (1978b) reported abnormally high returns 24 months after dividend increases and abnormally low returns over 24 months after dividend decreases He made no attempt to isolate the effect of dividend information from effects of other information However, dividend announcements almost always occur simultaneously with earnings announcements In their seminal paper, Ball and Brown (1968) formed estimates of the market's earnings forecast and then observed the reactions in a good news portfolio consisting of companies that had higher actual earnings than estimated, and in a bad news portfolio consisting of companies that had smaller actual earnings than estimated They found that the average cumulative abnormal returns of good/bad news portfolios occurred before the actual earnings announcements These results suggested that prices in the NYSE continuously adjusted in an unbiased manner to earnings' information But subsequent

[18] Brennan and Copeland (1988)

studies of return behaviour of ranked portfolios following the earnings announcement yield conflicting results, i.e. the post-earnings announcement drift anomaly[19]-- Abnormal returns are positive (negative) after earnings announcement for several months following large increases (decreases) in earnings relative to expectations.

In addition to these company specific announcements mentioned above, other tests have concerned new product or product innovation announcements of firms[20], the exchange market information and characteristics, i.e. block trades[21], company mergers[22], the number of shares held short[23], the suspension of trading for a security[24], the initial issuance of the securities[25], and second-hand information[26]. These tests by and large are supportive of semi-strong market efficiency.

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[19] U.S. evidence: Jones and Litzenberger (1970), Joy, Litzenberger, and McEnally (1977), Watts (1978), Rendleman, Jones, and Latane (1982), Foster, Olsen, and Shevlin (1984), Bernard and Thomas (1989), and Freeman and Tse (1989).
Finnish evidence: Martikainen, Rothovius, and Yli-Olli(1993).

[20] Eddy and Saunder (1980), Wittink, Ryans, and Burrus (1982), Chaney and Devinney (1992).

[21] Guthman and Bakay (1965), Kraus and Stoll (1972), Scholes (1972), Grier and Albin (1973), Carey (1977), Dann, Mayers, and Raab (1977), Dodd and Ruback (1977), Ball and Finn (1989), and Kumar, Sarin, and Shastri (1992).

[22] Franks, Broyles, and Hecht (1977), Asquith (1983), Brown and Warner (1985), Lakonishok and Vermaelen (1990), Franks, Harris, and Titman (1991), and Agrawal, Jaffe, and Mandelker (1992).

[23] Figlewski (1981), and Vu and Caster (1987).

[24] Hopewell and Schwartz (1976), and Kryzanowski (1979).

[25] McDonald and Fisher (1972), Ibbotson (1975), Hess and Frost (1982).

[26] This means that stock markets react to the announcements of financial analysts. e.g. Earnings' announcement: Joy, Litzenberger, and McEnally (1977), Ball (1978), Brown (1988), Bernard and Thomas (1989), Abarbanell and Bernard (1992), and Martikainen, Rothovius, and Yli-Olli (1993). Value line's announcement: Black (1973), and Copeland and Mayers (1982). The day of publication to articles: Davies and Canes (1978), Foster (1987), and Wijmenga (1990). Qualified audit opinion: Firth (1978), Elliott (1982), Fleak and Wilson (1994), and Klock (1994).

2.3.3. Strong-Form Market Efficiency

The market is efficient in the strong sense if share prices have impounded not only public but also private information, meaning that no one can expect to gain excess returns by acquiring or analysing information which is not yet published.

Lorie and Niederhoffer (1968) investigated the performance of NYSE stocks following months in which there were at least two more buyers than sellers or vice versa among the insiders of a company. They found that a security experiencing an intensive buying month would be more likely to outperform the Dow Jones Industrials and a security experiencing an intensive selling month would more likely to perform worse than the Dow Jones Industrials in the following six months. Jaffe (1974) defined an intensive trading month as one during which there were at least three instead of two more insiders buying than selling, or vice versa, and confirmed Lorie and Niederhoffer's finding. A study by Finnerty (1976) argued that using an intensive trading group to test the strong form hypothesis would bias the result. Then he tested the entire population of insiders and still corroborated Jaffe's conclusions that, on average, insiders do earn higher returns on their share holdings than outsiders. Further, Penman (1982) investigated insiders' trading around the date of their forecasts of the annual earnings, and discovered that insiders tended to purchase shares before their forecast announcements and sell shares after the announcements. Seyhun (1986) also investigated differences in the quality of information that different insiders possess and found that insiders who are expected to know more information of the firm (such as chairmen of the board of directors) possess better predictive ability.

A number of researchers have attempted to examine the performance of mutual funds. For example, Jensen (1968) developed absolute measures of performance (each portfolio performance is relative to an absolute standard as represented by the capital asset pricing model) instead of relative measures of performance (each portfolio performance is relative to other portfolios) and found disappointing results for the mutual-fund industry. Over the 10-year period 1955-64, the mutual funds were not able to outperform a buy-and-hold strategy even when fund returns were measured gross of management expenses and brokerage costs. Mains (1977) re-examined Jensen's work using monthly data instead of annual data in order to avoid understating the mutual fund rates of return and found that mutual funds were able to outperform the market, but net performance of mutual funds (net of operating expense, management fees, and brokerage commissions) is the same as that for a naive investment strategy. These results[27] indicated that mutual funds did not yield abnormally high returns on average and thus supported the strong form of the efficient market hypothesis. However, Chang and Lewellen (1984), Ippolito (1989) employed the Sharpe-Lintner market line as the benchmark to evaluate the investment performance of mutual funds and suggested that average returns to fund investors are enough to cover the expenses and management fees they pay to fund managers.

Recently, Dimson and Marsh (1984) published an extensive review of previous research on analysts' and stock brokers' forecasts. Further, they examined correlations between 400 actual and forecasted returns made for 200 of the largest U.K. shares provided by 35 different firms of analysts. Their results indicated evidence of

[27] Schlarbaum, Lewellen, and Lease (1978), and Kon and Jen (1979).

forecasting ability potentially useful in fund trading. Furthermore, Elton, Gruber, and Grossman (1986) chose a large data set carefully designed not to suffer from selection or survivorship bias and found that both a change in brokerage firm recommendations and the recommendations themselves contained information. De Bondt and Thaler (1990) tested whether market professionals, institutional brokers, are rational when forecasting earnings and found that, as in the case of naive investors, market professionals overreact to the actual earnings. Their paper ended with the inconclusive question: "after all, are not these practitioners the very same 'smart money' that is supposed to keep markets rational?"

Although most empirical studies seemed to support the efficient market hypothesis in the 1960s and the early 1970s, some doubters have emerged since the late 1970s finding some evidence of predictable variation in security returns. The following sections in this chapter review some anomalies which have been recorded in the literature. Other evidence appearing directly to refute the hypothesis, such as mean reversion, will be reviewed in chapter 6.

2.4. Anomalous Stock Market Price Behaviour

2.4.1. Firm Size Effect

One important anomaly which interests both academics and practitioners is the "firm size effect". Banz (1981) was the first to document this phenomenon. He found that, in the 1936-1975 period, there was a negative relationship between the total market value of a NYSE common stock and its return. The volume of empirical evidence,-- e g Dowen and Bauman (1986), Keown, Neustel, and Pinkerton (1986), Tseng (1988), Fama and French (1992) and Badrinath and Kini (1994) -- following Banz's (1981) seminal paper has firmly substantiated the existence of the size anomaly in stock price behaviour

We know that among the firms that most academic researchers consider "small" are those firms that have small total market capitalisation But some of the academic researchers regard "small" firms as those that have high dividend yields, those have low P/E ratios, or those with low production efficiency and high financial leverage Much of the research has attempted to convey a more complete characterisation of the firm size anomaly Specifically, a conceptually separate explanation has been put forward called the neglected firm effect[28]-- Arbel (1985) suggested that stocks of the neglected firms, suffer greater information deficiency, are less widely held by institutional investors and provide higher returns

The firm size effect is not confined to the U S market only, similar results have been reported for Australia (Brown, Keim, Kleidon and Marsh (1983)), Canada (Berges, McConnell and Schlarbaum (1984)), Japan (Nakamura and Tarada (1984)), Singapore (Wong and Lye (1990)), and U K (Levis (1985),(1989)) Levis (1985) documented a 6 5% p a premium for smaller U K firms over the period January 1958 to December 1982

[28] Arbel and Strebel (1982),(1983), Arbel, Carvell and Strebel (1983), Barry and Brown (1984),(1985),(1986), Dowen and Bauman (1986), Carvell and Strebel (1987), and Jahera and Lloyd (1989)

Several repeated attempts have been made to explain away the firm size anomaly (a) infrequent trading Roll (1981) suggested the firm size effect may be a statistical artefact of improperly measured risk due to the less frequent trading of small firms, (b) tax effect most of the small size premium can be attributed to one single month -- January, because the tax-loss-selling pressure which will be mentioned in section 2 4 2 (c) transaction cost[29] small firms' stocks tend to have lower prices and higher bid-ask spreads, so transaction costs are relatively high, (d) non-stationarity of beta Christie and Hertzel (1981) argued that a firm has recently become "small" has, other things equal, an increase in the risk of its equity which accompanies an increasing leverage Consequently, historical estimates of beta that assume such risk is constant over time will underestimate the risk and overstate average risk-adjusted returns of the stocks However, Reinganum (1982) found that a misestimation of beta in the market model (after adjusting the betas of smaller firms for thin trading using Dimson's (1979) method) could not explain completely the abnormal returns for small firms, and furthermore when he (1981) used an arbitrage pricing model to estimate the expected returns, he still failed to explain the small-firm effect

Apart from these explanations mentioned above, Schwert (1983), and Dimson and Marsh (1989) provided comprehensive summaries for most of the explanation However, these hypotheses cannot or only partially can explain the odd firm size anomaly

[29] Schultz (1983), Stoll and Whaley (1983), and Krueger and Johnson (1991)

2.4.2. January Effect (Turn-of-the-Year Effect)

In 1976, Rozeff and Kinney first documented the "January effect", that the mean return for January is higher than for other months Following Rozeff and Kinney's finding of a January seasonal, one empirical researcher after another has found that the turn-of-the year effect reflects the "small-firm size effect"[30], that is to say, small stocks have unusually high returns that are especially pronounced in January Moreover, Keim (1983) found that more than fifty percent of the January premium during 1963-1979 is attributable to large abnormal returns during the first week of trading in the year[31], particularly on the first trading day

Another turn-of-the-year phenomenon demonstrated by Roll (1983), Lakonishok and Smidt (1984), Ritter (1988), Keim (1989), Clark, McConnell, and Singh (1992), and Griffiths and White (1993) that the year-end effect may be due in part to a shift from active transactions at the bid price in December to transactions at the ask price in January This systematic trading pattern introduces measurement error into returns when computed with closing bid or ask prices, especially for lower-priced stocks, since the bid-ask spread tends to be proportionately larger for them

A number of frameworks have been proposed to explain the turn-of-the-year effect These causes include what can be termed (a) the tax-loss-selling hypothesis[32],

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[30] Banz (1981), Blume and Stambaugh (1983), Keim (1983), Reinganum (1983), Roll (1983)

[31] Roll (1983) found that the five days of the year, the last trading day of December and the first 4 trading days of January, with the largest returns for all securities

[32] U S evidences Branch (1977), Dyl (1977), Givoly and Ovadia (1983), Schultz (1985), Chan (1986), Jones, Pearce, and Wilson (1987), Tinic, Barone-Adesi, and West (1987), Ritter and Ziemba (1988), Jones, Lee, and Apenbrink (1991), Griffiths and White (1993)
Canada evidences: Berges, McConnell and Schlarbaum (1984)

Brown, Keim, Kleidon, and Marsh (1983) gave a definition of the tax-loss-selling hypothesis as that tax laws influence investors' portfolio decisions by encouraging the sale of securities that have experienced recent price declines so that the (short-term) capital loss can be offset against taxable income Subsequently, in the new year prices bounce up in the absence of selling pressure, (b) the parking-the-proceeds hypothesis[33] whereby individuals sell securities at the end of the taxation year in order to realise the losses for tax purposes Some of the proceeds from December's tax-motivated sales are not immediately reinvested, but instead are held until January This may produce the pressure of buying stocks, (c) the portfolio-rebalancing hypothesis: this hypothesis developed by Haugen and Lakonishok (1988), Ritter (1988), and Ritter and Chopra (1989) asserts that the January effect is caused by systematic shifts in the portfolio holdings of investors at the turn of the year For example, institutional investors improve the appearance of their portfolios at year end by engaging in "window dressing", that is by selling losing stocks and buying stocks that have appreciated during the year When the year is over, they try to buy the stocks of smaller companies that they perceive to be undervalued, and (d) the intergenerational transfer hypothesis: recently, Gamble(1993) put forth the intergenerational transfer idea to explain the turn-of-the-year effect He reported the transfer of wealth, which usually happens at the Christmas gift-giving season, from older to younger investors causes a change in the tastes and preferences of the typical investor, in favour of smaller, newer, cheaper, riskier assets.

U.K. evidence: Reinganum and Shapiro (1987)
Australian: Gultekin and Gultekin (1983)
International evidences: Lee (1992)

[33] Haugen and Lakonishok (1988), Ritter (1988), Griffiths and White (1993)

Other explanations include risk-mismeasurement[34] caused by infrequent trading of securities, the information-release/insider-trading hypothesis, the stringency of monetary policy, database errors etc None of these appear to be able to explain the January effect completely It seems that the turn-of-the-year effect is caused by a number of simultaneous factors Hence it will be difficult to explain the effect with any one model

2.4.3. Monthly Effect (Turn-of-the-Month Effect[35])

Recently, some academic studies explore another seasonal anomaly in stock returns identified first by Ariel (1987) as the "monthly effect" and is not a manifestation of the January effect Ariel (1987) reported that the mean return for U S stocks is positive during a period which includes the last day and first half of the calendar months and indistinguishable from zero during the rest of the month Jaffe and Westerfield (1989) found a similar effect in Australia, the reverse effect in Japan, and not much significant effect in Canada and U K But Lakonishok and Smidt (1988), and Cadsby and Ratner (1992) examining the turn-of-the-month effect in ten stock markets found the phenomenon in the U K , Australia, Switzerland and West Germany when the turn-of-the-month is defined as the last and first three days of the month Judging from these empirical results, we notice that results of tests comparing returns in the first and second halves of the month differ from results of tests of the turn-of-the-month effects

[34] Officer (1975)
[35] Ziemba (1989), and Lauterbach and Ungar (1992) provided evidence of turn-of-the-month effects in Japan and Israel, respectively

There are some explanations for the documented monthly (or turn-of-the-month) effect in stock returns: (a) the liquidation hypothesis Ogden (1987),(1990) suggested that the turn of each calendar month is a typical payoff date for accrued real wages, dividends, interest and principal payments, and other liabilities, and the reinvestment of these economic entities induces a surge in stock returns at the turn-of-the-month stock returns, (b) the timing of earnings announcements hypothesis[36] Penman (1987) reported that aggregate corporate good earnings news tend to be released during the first half-month in calendar quarters 2 through 4, whereas bad earnings news is often suppressed and more likely to be reported to the market in other periods

Other possible explanations include the portfolio-rebalancing hypothesis (see section 2.4.2. (c)), and specialist related biases

2.4.4. Weekend Effect (Turn-of-the-Week Effect)

The weekend effect[37] is the tendency for holding period returns to be lower on Monday than on other days of the week. The significant negative return is generally found on Mondays in U.S., Canada and U.K., but on Tuesdays in France, Japan, Australia and Singapore. Fields (1931) first documented the weekend effect. He

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[36] McNichols (1987)

[37] International evidences: Condoyanni, O'Hanlon, and Ward (1987), Kim (1988), Aggarwal and Rivoli (1989), Jaffe, Westerfield and Ma (1989)

U.K. evidences: Board and Sutcliffe (1988), O'Hanlon (1988)

Canada evidence: Bishara (1989)

Japan evidences: Kato (1990), Ziemba (1993) examined the pattern of the Dow Jones Industrial Average (DJIA) for the period 1915-1930 (the period in which the New York Stock Exchange still traded on Saturdays), and found that prices tended to rise on Saturdays After Fields's study, Cross (1973), French (1980), Gibbons and Hess (1981), and Lakonishok and Levi (1982) etc used U S daily close-to-close returns and found that the mean Monday return was systematically negative As French carefully notes, this finding runs counter to both of the two hypotheses--the calendar time hypothesis(expected stock returns should be higher on Monday to compensate for the longer holding period) and the trading time hypothesis (expected stock returns should be equal on different days)

Some plausible hypotheses have been suggested to explain the weekend anomaly (a) the settlement periods hypothesis[38] a transaction taking place on one day need not be settled until several business days later For example, a U S stock purchased on a Friday is settled ten days[39] after the event whereas a U S stock purchased on a Monday is settled eight days[40] afterwards There ought to be two days more interest built in to the Friday stock price than the Monday stock price, (b) the information timing hypothesis[41] Dyl and Maberly(1988) suggested that the distribution of "good news" and "bad news" is not even across the week and that the announcement of bad news tends to be released after Friday's market closing Rogalski (1984), Harris (1986), and Smirlock an Starks's (1986) found that the negative returns

[38] Lakonishok and Levi (1982), Theobald and Price (1984), Dyl and Martin (1985), Jaffe and Westerfield (1985)
Franch evidence Sonik (1990), Solnik and Bousquet (1990)
[39] Five business days for settlement, one day for check clearing, and four weekend days
[40] Six business days plus two weekend days And before February 1968, the settlement/clearing period was seven calendar days for all U S common stock purchases
[41] Schatzberg and Datta (1992), Defusco, McCabe, and Yook (1993), Fishe, Gosnell, and Lasser (1993), Abraham and Ikenberry (1994).

have shifted backward in time as information availability increased with new technology. Smirlock and Starks used the DJIA to investigate weekend effect and found that the negative Monday return occurred during the entire trading day in the 1963-1968 period. From 1968-74 the negative Monday returns converged on the opening hours of Monday trading. Since 1974 the majority of the negative Monday returns occurred between Friday close and Monday opening. Finally, (c) the investor psychology hypothesis[42]: investors are influenced by moods, perceptions and emotions that systematically differ across the days of the week -- ex. good moods on Fridays and bad moods on Mondays.

Other explanations involve specialist operations[43], systematic trading patterns, measurement error, ex-dividend behaviour etc. No single factor has completely explained the weekend effect.

2.4.5. Holiday Effect

Sixty years ago, Fields (1934) had found that the DJIA revealed a disproportionate frequency of advances on trading days preceding long holidays. And a number of financial practitioners such as Merrill (1966) and Fosback (1976) who studied the DJIA and S & P 500 indices respectively have also noted the pre holiday anomaly. Only recently has the holiday effect been investigated in the academic literature[44]. Pettengill (1989) reported that small firms outperform large ones both on

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[42] Coursey and Dyl (1986), Miller (1988), Rystrom and Benson (1989)
[43] Keim and Stambaugh (1984), Miller (1988)
[44] Lakonishok and Smidt (1988), Pettengill (1989), Ariel (1990), Cadsby and Ratner (1992), Kim and Park (1994)

January and non-January pre holidays Ariel (1990) and Kim and Park (1994), however, found that the holiday effect is not confined to firm size and is not a manifestation of the January effect and the weekend effect Kim and Park (1994) found that the holiday effect exists also in the U K and Japanese stock markets independently of the U S stock market

A number of possible hypotheses including systematic shifts between bid and ask prices around holidays, activity by specialists at the market close and specific clienteles' investment preferences[45] also have been raised to account for the holiday effect

2.4.6. Intraday Effects (Time-of-the-day Effect)

Academic scrutiny of the time-of-day effect has only recently been made possible by the availability of high-frequency data bases Owing to the large amount of data needed for intraday studies, the sample periods are relatively short Wood, McInish, and Ord (1985) examined NYSE minute-by-minute market return data for two time periods -- the six months from September 1971 to February 1972 and calendar year 1982, Harris (1986) examined NYSE 15-minute intraday return data from December 1981 to January 1983, and Jain and Joh (1988) examined S&P 500 hourly data from 1979 to 1983 They all found that the stock returns (except on Monday) have the U-shaped intraday patterns, that is, returns are positive at the beginning and at the end of the trading day

[45] For more detail refer to Keim (1989)

Jain and Joh (1988) showed that there is a strong positive correlation between contemporaneous NYSE volume and absolute S&P 500 returns. Wood, McInish, and Ord (1985) and McInish and Wood (1990) also found that the unusually high opening and closing returns are more variable than returns during the rest of the day, and McInish and Wood (1990) documented a U-shaped intraday pattern in one-minute index returns autocorrelation The results of these empirical analyses of stock market intraday patterns are consistent with a number of explanations including the information arrival hypothesis[46] (Unanticipated good news towards the close might not be fully reflected in prices until the next morning), nonsynchronous trading[47] , systematic errors in the data, and changes in bid/ask spreads

2.4.7. The Price/ Earnings (P/E Ratio) Effect

The price-earnings (P/E) financial ratio -- the ratio of the market price of a stock to its average earnings -- has long been one of the most scrutinised and studied measures by equity analysts in assessing equity value since they found that returns on stocks with low P/E ratios tend to be larger than stocks with high P/E ratios Basu (1975), (1977) explored NYSE data over the period April 1957-March 1971 and observed an inverse relationship between risk-adjusted returns and P/E ratio whether risk-adjusted returns were measured by using the original CAPM or measured by the zero-beta version of the CAPM. Ball (1978) pointed out that E/P ratio can be viewed as a direct proxy for expect returns since "E/P yields" are likely to be correlated with

[46] Admati and Pfleiderer (1988), Brennan and Subrahmanyam (1995).
[47] McInish and Wood (1985),(1990)

"true yields" Goodman and Peavy (1983) addressed that P/E effect might be a surrogate for an industry effect because firms in the same industry tend to cluster in the same P/E group. By using the hypothesised industry-normalised P/E ratio[48], or "price-earning relative (PER)", and controlling for the small firm and infrequent trading effects, they still found that low PER portfolios have more excess returns than high PER portfolios.

If the stock market is inefficient, one potential explanation of the P/E effect is inappropriate market responses to information, i.e. exaggerated optimism leads to stocks with high P/E ratios and exaggerated pessimism leads stocks with low P/E ratio, so the inverse relationship between risk-adjusted return and P/E ratio is just evidence of mean reversion. Keown, Pinkerton, and Chen (1987), however, allowed beta to vary with time and suggested that portfolios with extreme P/E (low P/E or high P/E) ratios possess abnormally high levels of unsystematic risk.

2.4.8. The Value Line Enigma

The value Line Investment Survey, one of the largest investment advisory services, assigns approximately 1770 ranked common stocks into 5 groups based on historical and forecast information such as P/E ratios and price and earnings momentum. The Value Line timeliness rankings are intended to indicate the potential relative price performance for the next twelve months. Early Value Line performance evaluation studies by Black (1973), Holloway (1981), and Copeland and Mayers

[48] $PER = PE_i / PE_I$, where PE_i = the PE ratio for security, PE_I = the mean PE ratio for the related industry group.

(1982) found that after adjusting for beta risk, the firms with rank 1 which indicates most favourable performance outperformed the firms with rank 5. Huberman and Kandel (1987) showed that the Value Line's better performance can be explained by Stickel's (1985) findings that the effect of Value Line rankings' changes in Small firms' stocks is bigger than that in large firms' stocks. Specifically, Peterson (1987) used daily prices to examine whether initial reviews of securities by the Value Line convey significant information to the market. They found statistically significant abnormal returns for portfolios simply over the three trading days around release of the information, the market appears to be efficient after this three-day period.

2.4.9. Interrelation Between the Effects

Financial economists have also found complex relationships between anomalies. For instance, Reinganum (1981), Banz and Breen (1986), and Rogers (1988) argued that the size effect subsumes the E/P effect, while Basu (1983) found to the contrary. Cook and Rozeff (1984), and Jaffe, Keim, and Westerfield (1989) concluded that returns are related to firm size, E/P ratio, and the month of January. Fama and French (1993), (1995) suspected that there is an underlying economic state variable that produces variation in earnings and returns related to size and book-to-market equity that is not captured by an overall market factor. Keim (1985) indicated a strong interaction between dividend yield and firm size. Krueger (1990), and Krueger and Johnson (1991) lately examined the seasonal explanatory power of three anomalies -- firm size, P/E ratio, and Value Line's Timeliness rankings, they found the significance of firm size is primarily in the first quarter, Value Line's Timeliness rankings are significant in the second quarter, P/E ratio is significant in the third quarter, and both Timeliness rankings and the interaction of size and Value Line Timeliness rankings is significant in the fourth quarter -- after controlling for information deficiencies and adjusting the single-index model to reflect transactions cost, beta's regression tendency, and the availability of alternative market proxies in the research is exercised

More recently, some researchers turn to use a wide variety of performance measures in explaining returns For example, Friend and Lang (1988) scrutinised the Standard and Poor's Quality Rankings[49] assigned by security analysts and found that the quality rankings are superior over beta and variance measures of risk in explaining returns and in subsuming the size effect as well Additionally, Badrinath and Kini (1994) introduced Tobin's q ratio[50] as a variable which could potentially have a connection with size and E/P effects, and indicated that the control for Tobin's q diminished the E/P effect but didn't change the magnitude of the size effect

The evidence for interrelations between the different anomalous effects for markets outside the U.S. is still scarce Levis (1989) scrutinised the stock price behaviour of firms on the London Stock Exchange over the period April 1956 to March 1985 in search for empirical evidence regarding the possible interrelations of the

[49] The Standard and Poor's (S&P) quality rankings are based on the stability and growth of both earnings and dividends After 1976, the quality rankings start to set minimum size limits For more details refer to S&P Stock Guide 1968.I -- 1982.I

[50] Tobin's q ratio is defined as the ratio of the firm's market value to the replacement cost of its assets. In Badrinath and Kini(1994), the market value of the firm is estimated by summing the market value for its common stock, preferred stock, and debt The replacement cost of the assets of the firms is: R=TA+(RP-BP)+(RI-BI)-DT , where TA is total assets, including current assets, RP is the replacement cost of plant and equipment; BP is its book value; RI is the replacement cost of inventories, BI is their book value; and DT is the book value of deferred taxes More details defer to Lindenberg and Ross (1981), Smirlock, Gilligan, and Marshall (1984), and MacFarland (1987)

market size, dividend yield, PE multiple and share price effects He concluded that the dividend yield and the PE multiple are more important in explaining stock returns than the size and share price effects[51]

In sum, there must be a number of interrelated hypotheses on the factors affecting stock returns and they may not be robust to different sample data

2.4.10. Excess Volatility

Many of these anomalies mentioned above are closely related, and it is, therefore, often difficult to distinguish the effect of one anomaly from that of another The recent stock market crashes, in 1987 and in 1989 have rekindled[52] interest in stock market volatility Two pioneering papers, LeRoy and Porter (1981) and Shiller (1981), used the unconditional variance bounds inequality restrictions in which the variance of actual prices is compared with the variance estimate of fundamental prices calculated using the constant discount rate dividend valuation model to test the volatility of U S equity prices Both of them found that observed stock prices are more volatile than the rational price series Although the unconditional variance bounds theorems of Shiller's (1981) may be correct under restrictive assumptions, many of the critical issues, for example, Flavin (1983), Kleidon (1986), Marsh and Merton (1986), focused their arguments on the statistical properties of the tests

[51] The empirical results of Blume and Husic (1973), Stoll and Whalley (1983) and Blume and Stambaugh (1983) revealed that there is a negative relation between share prices and stock returns
[52] West (1988), Le Roy (1989), Cochrane (1991), and Kupiec (1993) gave excellent reviews of stock market volatility

In most of the subsequent work, the original variance-bound tests were improved by designing more robust expected dividends which are non-stationary[53] and by relaxing the assumption of constant expected returns[54] The results of these tests were still consistent with Shiller's, though at a lower significant level, that sock prices are excessively volatile Moreover, with the more recent evidence on return predictability (e g long-term mean-reversion in stock prices to be covered in more depth in chapter 6), the finding of excess volatility seemed to imply that expected returns vary through time

In order to see whether the variation in expected returns supports the market efficient hypotheses, many empirical studies attempted to find causes affecting the movements of stock prices

(1) economic fundamentals change[55] changes in macroeconomic factors (e g expected inflation rates, interest rates, unemployment rates, term structure variables, tax laws) or firm-specific factors (e g dividends yields) will induce changes in dividend expectations and, therefore, in expected returns,

(2) institutional investors[56]: the institutional investors tend to have the same views about particular shares and have faster market reactions,

(3) dispersion of analysts' forecasts[57] using the Black-Scholes option pricing formula to estimate the implied variance of stock returns[58], Ajinkya and Gift (1985) found that

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[53] Mankiw, Romer, and Shapiro (1985), Scott (1985), and West (1988)
[54] Le Roy and Civitia (1981), Grossman and Shiller (1981), Mankiw, Romer, and Shapiro (1989), and Scott (1990)
[55] French and Roll (1986), Roll (1988), (1989), Schwert (1988), Cutler, Poterba, and Summers (1989), Fama (1990), and McQueen and Roley (1990)
[56] Grier and Albin (1973), Dobbins and Greenwood (1975), Ward and Saunders (1977), Brealey, Byrne and Dimson (1978), Reilly and Wachowicz (1979), and Lee and Ward (1980)
[57] Malkiel (1981), Givoly and Lakonishok (1984), and O'Hanlon (1990)

the cross-sectional dispersion, in financial analysts' forecasts of earnings per share for a firm, has significant power in explaining stock return volatility,

(4) program trading[59] program trading is the technique which is exercised by simply putting a new inflow of funds in a program-trade order through a computer for simultaneous purchase or sale of all the stocks Such strategies may change market sentiment and affect the prices of shares with great magnitude,

and (5) margin regulations Hardouvelis's (1988) showed a significant negative relationship between initial margin requirements and stock market volatility Consistent with those findings of Moore (1966), Officer (1973), and Schwert (1988), Hsieh and Miller (1990) found that when the market fell (rose) and volatility rose (fell), the Federal Reserve System tended to lower (raise) margins

2.5. End Note

In the first part of this chapter, I have stated the development of the three risk-adjusted models in the capital markets and the existing empirical evidence relating to their validity Then, I started the second part of this chapter with three risk-unadjusted models of the time series behaviour of prices, followed by an overview of stock market efficiencies Finally, some major anomalies recently cited in the financial literature have been provided in the third part of this review chapter and some possible explanations for each anomaly have been offered last as well

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[58] Day and Lewis (1988), Hodgson (1988), Bates (1990), Gemmill (1990), and Jen and Whaley (1990)

[59] Stoll and Whaley (1987), (1990)

In the following three chapters, I will report the results of empirical tests of the predictive ability of five various models. Chapter 3 documents the derivation of an alternative model -- the Leveraged Asset Pricing Theory (LAPT). Chapter 4 describes data sources and methodology of this empirical test and, finally, the empirical results for comparing the predictive ability of the five different models will be documented in Chapter 5.

CHAPTER 3

AN ASSET PRICING MODEL UNIFYING THE ARBITRAGE PRICING THEORY AND THE MM THEORY OF CAPITAL STRUCTURE[1]

3.1. Introduction

The systematic risk coefficient, defined on the single-index model (the market model), expresses the expected response of an asset or portfolio excess returns to excess returns on the market portfolio. This sensitivity of stock returns to market returns is usually referred to as "Beta". Unfortunately, the "expected" beta is unlikely to be estimated accurately due to the large degree of uncertainty associated with security returns. Carefully comparing different ways of estimating beta will give us an insight into the characteristics of the beta factor.

There are two broad approaches to estimating beta, the first and the most frequently used approach for estimating beta is to use historical price behaviour. The second incorporates fundamental data (e.g. accounting data). As an example of the first approach, Sharpe and Cooper (1972) divided shares into risk deciles on the basis of their estimated beta and investigated the stability in beta. They found that there is a high probability of the value of beta falling into similar risk classes in two successive, non-overlapping periods or within one or two deciles of its classification in the earlier period. Their results offered the powerful evidence that "historical betas" provide useful information about future betas as estimated betas in two consecutive time

[1] I am deeply indebted to my supervisor, Dr. Jack E. Broyles, who gave the original idea of constructing the LAPT by unifying the APT and the MM theory.

periods tend to lie on similar risk brackets. However, as a risk measure, it is plausible that beta of equity may be related to the capital structure of the firm and conceivably could change in response to changes in the uncertainty in the economy as well. The second approach for estimating beta is to use firm's fundamental data (e.g. E/P ratio, leverage, etc.). Empirical studies have used accounting data to examine the ability of the conventional models in explaining and predicting "fundamental betas" and equity return. If the value of a beta can be expected to change with, for example, capital structure, betas may be predictable to some extent.

The purpose of this chapter is to try to construct a pricing model, the Leveraged Asset Pricing Theory (LAPT), which may combine the advantages of both historical and fundamental betas without being subject to the disadvantages of each. Before deriving the LAPT, we start with a brief review of the existing literature concerning beta estimation in order to have some idea of its characteristics.

Sections 3.2. and 3.3. show the two standard methods of estimating betas. These techniques are classified into two types according to the data, historical and fundamental data, used for estimation. Then, the relative strengths and weaknesses of historical and fundamental betas are discussed in section 3.4. Section 3.5. starts with a brief review of the existing evidence on the importance of considering one factor, leverage, in asset pricing, which motivates us to derive a leveraged asset pricing model. Finally, the derivation and the properties of the Leveraged Asset Pricing Theory are described in section 3.6. and 3.7., respectively.

3.2. Historical Betas

The historical approach to estimating future betas usually uses historical betas obtained simply from past data as estimates of future betas In order to extract more information from historical data, some correcting techniques have been developed to improve the historical approach In order to explore the relative strengths and weaknesses of these techniques, it would be useful to know the behaviour of estimated betas through time For instance, how much association is there between the estimated betas in one period and the estimated betas in an adjacent period?

Using straightforward regression analysis, Blume (1971) used data over a 35-year period divided into five consecutive periods of seven years and examined the stationarity of the betas for portfolios over time He computed the beta of each common stock listed on the New York Stock Exchange by regressing the monthly returns of each security on the monthly market returns index for the first seven-year period, 7/26 ~ 6/33, ranked these estimated betas in ascending order, and grouped securities, from the smallest to largest estimates of beta, into n-stock portfolios Blume let the number of securities n in a portfolio be 1, 2, 4, 7, 10, 20, 35, and 50 He then examined how highly correlated the portfolio betas are for this seven-year period and the next non-overlapping seven-year period, 7/33 ~ 6/40 Taking 7/33 ~ 6/40, 7/40 ~ 6/47, 7/47 ~ 6/54, and 7/54 ~ 6/61 as grouping periods, the process was repeated for each of these periods The results supported consistently that the larger the number of securities in a portfolio, the more information its beta estimate contains about the future beta on the portfolio It is understandable that the estimated betas of individual securities are measured with random errors, and these errors will tend to cancel out when securities are combined. What Blume's paper showed, however, is that estimated betas do change through time. Other empirical and theoretical studies, Fisher and Kamin (1972), Gonedes (1973), and Meyers (1973), have consistently suggested that beta coefficients cannot be considered stationary.

The next questions that could be raised are "How do estimated betas behave through time? Is there any pattern or tendency?" Both Levy (1971) and Blume(1971),(1975) found the tendency for estimated betas in the forecasting period to be closer to the grand mean of all betas than the estimates of these betas obtained from the historical data.

Blume (1971) introduced the regression method. He regressed the estimated β_{t+1}'s in the period 7/61 ~6/68 on the estimated β_t's in the period 7/54 ~ 6/61 (the previous period) and obtained the estimated equation: $\hat{\beta}_{t+1} = 0.399 + 0.546\beta_t$. The slope coefficient is less than one, that means, the relationship has a function that lowers high values of historical beta (when $\beta_t \geq 0.879$) and raises low values of historical beta (when $\beta_t \leq 0.879$), to reflect the tendency of the forecasted betas. Assuming that this regression tendency towards the mean is stationary over time, then the forecasted betas for the period 7/68 ~ 6/75 could be computed from this equation. Moreover, Blume compared the two estimated betas, unadjusted (β_{t+1}) and adjusted ($\hat{\beta}_{t+2} = 0.399 + 0.546\beta_{t+1}$), to the actual estimated beta (β_{t+2}) and concluded that the adjusted assessments ($\hat{\beta}_{t+2}$) are more accurate than the unadjusted assessments (β_{t+1})[2]

The assumption of stationarity mentioned above implies a continuous trend the movement of betas in time period t+2 relative to the movement of betas in time period t+1 is similar to the movement of betas in time period t+1 relative to that of betas in time period t Unless there is a reason to believe in a continuous trend in beta, the beta obtained by this method might really be an estimate of the true historical beta obscured by measurement error A better way of avoiding forecasting a trend in betas is to take some average of the two values, β_t and β_{t+1}, in order to compensate for the possible error This kind technique which is widely used is called the Bayesian estimation technique

Both Levy (1971) and Blume (1971), (1975) found that estimated betas in the forecasting period tend to be closer to the grand mean of all betas than the estimates of these betas obtained from previous historical data Based on the Bayesian theory, Vasicek(1973) has suggested a procedure that consists of taking a weighted average of the unadjusted beta, β_t, and the average beta, $\bar{\beta}_t$, for the sample of stocks in the time period t to measure the tendency of the forecasted betas The forecast of beta for a security is obtained via this equation

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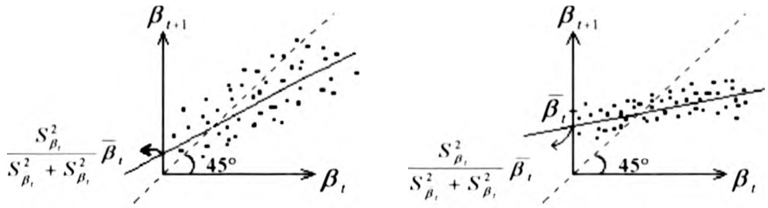
[2] The mean square errors were calculated by $\dfrac{\sum(\beta_{t+1}-\beta_{t+2})^2}{n}$ and $\dfrac{\sum(\hat{\beta}_{t+2}-\beta_{t+2})^2}{n}$, where β_{t+1} is the naive assessed value (unadjusted) of β_{t+2}, $\hat{\beta}_{t+2}$ is the assessed value (adjusted for the historical tendency of regression) of β_{t+2}, and n is the number of observations

$$\beta_{t+1} = \frac{S_{\beta_t}^{\;2}}{S_{\bar{\beta}_t}^{\;2} + S_{\beta_t}^{\;2}}\,\bar{\beta}_t + \frac{S_{\bar{\beta}_t}^{\;2}}{S_{\bar{\beta}_t}^{\;2} + S_{\beta_t}^{\;2}}\,\beta_t$$

$$\Longrightarrow \begin{cases} \beta_{t+1} \approx \beta_t & , \ if \ \ S_{\beta_t}^{\;2} << S_{\bar{\beta}_t}^{\;2} \\ \beta_{t+1} \approx \bar{\beta}_t & , \ if \ \ S_{\beta_t}^{\;2} >> S_{\bar{\beta}_t}^{\;2} \end{cases}$$

where $S_{\beta_t}^{\;2}$ is the variance of the individual beta,

$S_{\bar{\beta}_t}^{\;2}$ is the variance of the average beta in the sample



$$\begin{cases} if & S_{\beta_t}^{\;2} << S_{\bar{\beta}_t}^{\;2}, \\ then & \beta_{t+1} \approx \beta_t \end{cases} \qquad \begin{cases} if & S_{\beta_t}^{\;2} >> S_{\bar{\beta}_t}^{\;2}, \\ then & \beta_{t+1} \approx \bar{\beta}_t \end{cases}$$

Figure 3.1. Vasicek's Bayesian Technique

Figure 3.1 shows that if the variance of the individual beta ($S_{\beta_t}^{\;2}$) is much smaller than the sample variance ($S_{\bar{\beta}_t}^{\;2}$) in the time period t, the forecasted beta in the time period t+1 tends to follow the same value as the beta in the time period t. Similarly, if the variance of the individual beta is much larger than the sample variance in the time period t, the forecasted beta tends to "shrink" toward the average beta for the sample. That is why the Bayesian estimation technique is also called the "Shrinkage Method".

Although the Bayesian technique does not assume a consistent trend in forecasting beta as the Blume technique does, it tends to lower the average future beta (equally weighted). We know that the magnitude of standard errors of high beta stocks is usually larger compared with that of low beta stocks. So, high beta stocks are adjusted (shrunk) more toward the mean for forecasting the period than low beta stocks. This lowers the average future beta.

After introducing these adjustment techniques for historical betas, we should now examine how well they perform in forecasting betas. Klemkosky and Martin(1975) used the Mean Square Error(MSE) method as a measure of forecasting error to test the accuracy of three adjustment procedures -- Blume's technique, Vasicek's technique, and the Merrill Lynch procedure[3] -- and unadjusted betas over three five-year periods for both one-stock and 10-stock portfolios. They found that all three adjustment techniques consistently produced better predictors of future betas than the unadjusted betas did, implying that historical beta estimates are not unbiased predictors of the future value of betas. Moreover, Klemkosky and Martin decomposed MSE[4] into three components of forecast error -- the bias in the return predictions, the bias of overestimating high betas and underestimating low betas, and the unexplained random disturbance -- and investigated the source of forecast errors within each procedure. They concluded that Vasicek's Bayesian technique slightly outperformed

[3] A number of other ways can be used to represent the grand mean of all betas. For example, the Security Risk Evaluation service by Merrill Lynch, Pierce, Fenner & Smith, Inc. has used a simple weighting formula, $\beta_{t+1} = (1-k)\cdot 1 + k\beta_t$, to adjust their betas. Here, k is a constant common for all stocks. That is to say, they believe that the forecasted betas tend to be closer to one than the estimated betas from historical data.

[4] Theil (1966) decomposed mean square error (MSE) into statistical bias, inefficiency, and error. Clearly, if bias and inefficiency are foreseeable or predictable, then perhaps beta estimates can be improved by adjusting for these statistical deficiencies. These three Bayesian adjustment methods were designed to adjust beta estimates for bias and inefficiency.

both Blume's technique and the Merrill Lynch procedure Elton, Gruber, and Urich (1978) investigated the forecasting ability of alternative techniques in estimating future correlation coefficients, which could simplify the procedure of selecting optimal portfolios They provided further evidence implying that it is better to use either Blume's or Vasicek's adjustment rather than unadjusted beta to forecast future betas Another question raised is "Where does the bias of overestimating high beta or underestimating low beta come from? Can it be explained by any other variable?"

3.3. Fundamental Betas

Fundamental betas are predicted betas which are related to the underlying state of an economy and its expected trends We know that beta is a risk measure which provides a link between corporate returns and the market returns Any variable which influences a company's risk, relatively, would affect the value of its beta Most analysts would agree that any change in the firm's fundamentals (e g leverage, E/P ratio, etc) of the firm's stock will cause variations in its risk That is to say, they believe that an accurate prediction of risk will require the evaluation of the company response to its fundamentals

Several studies attempt to relate the beta of a stock to its fundamentals For example, Breen and Lerner (1973) used seven corporate variables -- the ratio of debt to equity (D/E), the ratio squared ($(D/E)^2$), the growth rate of earnings (G), the stability of the growth in earnings (SG), market size of company (S), dividend payout ratio (DP), and number of shares traded (N) -- to explained the valuations in beta values. For the year 1969, as a first step, they employed the single-index model, using the monthly company return and the monthly New York Stock Exchange (NYSE) index observations as inputs, to estimate the beta of each company for a 36 month period using ordinary least squares. The next step was to use the 36 month estimated beta of each company as the dependent variable and relate these betas to the seven corporate variables via multiple regression analysis. An equation of the following multiple regression form was estimated:

$$\hat{\beta}_i = a_0 + a_1(D/E) + a_2(D/E)^2 + a_3(G) + a_4(SG) + a_5(S) + a_6(DP) + a_7(N) + e_i \qquad (3.1)$$

where $\hat{\beta}_i$ is the estimated beta from step one of security i,

$a's$ are estimated response coefficients for all companies,

and e_i is a random error term of security i.

Other studies, such as Beaver, Kettler, and Scholes (1970) relate another set of seven fundamental variables (dividend payout, asset growth, leverage, liquidity, asset price, earning variability, and accounting beta), Rosenberg and Marathe (1975) relates 101 variables, which include historical values of beta, etc., to beta.

The significance of these fundamental variables in explaining the variation of estimated betas is not found to be consistent across studies, and the ability of the fundamental variables to aid in predicting future betas has been mixed. Some studies find large improvements in forecasting ability and significant reduction of the bias of misestimating betas, but others do not. For example, the results of Breen and Lerner's

(1973) study showed that many of the response coefficients were not significantly different from zero Though some of the reported coefficients appeared significantly different from zero, their significance were not robust over time Moreover, the overall unadjusted[5] determination coefficient, R^2, for the estimated regression model was not high It is no surprise that there was not a high correlation between the predicted betas and the chosen fundamentals given the noise in estimating the dependent variable, the beta The possible explanations of the different results between these empirical studies are either that the predicted betas are not adequate surrogates of the true betas or that the chosen fundamentals are not suitable for expressing the true relationship between a company's beta value and it's financial variables, or both

3.4. The Review of Historical and Fundamental Betas

The historical beta is the estimate of the past average beta which is obtained by regressing historical security returns on market returns It will be an unbiased predictor of the future value of beta if the expected difference between the true value of beta averaged over the past periods and the value of beta in the future is zero Rosenberg and Guy (1976a),(1976b) gave a review of the relative strengths and weakness of historical and fundamental betas They mentioned that the advantages of using an historical beta as the estimate of the future value of beta are that the historical beta directly measures the response of each stock to market movements The procedure is straightforward The disadvantage of this type of beta is that it responds to changes in

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[5] Adding more independent variables to the model can only increase R^2 and never reduce it The adjusted R^2, which will be mentioned in section 5.3., is suggested to be used as it recognises the number of independent variables in the model

the size or importance of the company's characteristics only after a long period of time has passed (depending on the sample size), and it might not reflect the company's characteristics or the underlying economic events properly or promptly For improving forecasting ability, it is necessary to incorporate the knowledge of fundamentals of the firm into predictions of future betas

Although the resulting fundamental beta can respond quickly to a change in the company's characteristics since it is computed directly from these characteristics, it assumes that the responsiveness of all betas (cross-sectional estimates) for all securities to an underlying fundamental variable is the same, for example, the estimated response coefficients, a's, in equation 3 1 are the same for all securities in the sample In addition, another approach proposed by Rosenberg and Marathe (1975) explains more of the variance of security return than did both the historical and the fundamental betas, although the process of going from specifying the 101 variables (the mixture of historical and fundamental variables) to the final prediction for the future value of beta is lengthy and tedious Furthermore, without a theoretical footing, like the macroeconomic form of the APT, the selection of fundamental variables and the relationships between estimated beta and these fundamental variables -- linear, multiplicative, exponential, curvilinear, etc -- are undecided For these reasons, the following sections try to construct an alternative model which may gain the advantages of each kind of beta without perhaps being subject to the disadvantages of these betas

3.5. Related Theoretical and Empirical Research

In the recent empirical evidence, the systematic risk measure, the beta factor, suggested by the CAPM has been found to be inadequate in explaining expected common stock returns. As mentioned in Chapter 2, the common stocks with smaller market capitalisation, higher earnings/price ratio, and lower share prices earn higher average returns after controlling for beta. For example, De Bondt and Thaler (1987), and Chan (1988) found stock prices behaving consistently with earnings movements. A decline (increase) in stock prices, meaning that a decline (increase) in market capitalisation, would imply an increase (decline) in debt/equity ratio (leverage), and hence systematic risk as measured by the CAPM stock betas. Ball and Kothari (1989) investigated recent evidence of negative serial correlation in security returns. Their results indicated a need for controlling for variables likely to be associated with relative risk changes, such as leverage, changing earnings, and changing dividend payout ratios. At the end of their review paper on mean reversion, De Bondt and Thaler (1989) suggested that "the real challenge facing the field is to develop new theories of asset pricing that are consistent with known empirical facts and offer new testable predictions." The motivation in this dissertation for deriving a leveraged asset pricing model is to bring this most important time-varying factor, leverage, more directly to bear in asset pricing by incorporating its effect on the systematic risk, beta, determining the returns on common stock.

In 1972, Hamada used both CRSP and Compustat yearly data for the period from 1948 to 1967 to test the difference between the observed common stock's systematic risk, β_l, and the unlevered systematic risk measure, β_u. The relationship is $\beta_l = \beta_u \left[1 + (1 - \tau)\frac{D}{E} \right]$, where τ is the corporate tax rate, D and E are market values of corporate debt and levered equity, respectively. He estimated β_l and β_u by employing market models, and found that, if the Modigliani and Miller (MM) theory[6] (1963) is correct, the leverage factor for most firms (which had major changes in their capital structures over the study's time period) explained approximately 21 to 24 percent of the value of the β_l. He suggested that the reason the relationship was not stronger is that small amounts of leverage cannot be discerned by the market. Simply using the market index to explain the structure of security returns is incomplete. Hill and Stone (1980), Chance (1982), and Mohr (1985) have provided additional empirical support for the Hamada risk decomposition approach. Many previous studies, Boness, Chen, and Jatusipitak (1974), and Rosenberg and Guy (1976) also have empirically verified the general positive relationship between systematic risk and leverage.

Recently, Bhandari (1988) found that the expected returns on common stocks are positively related to leverage even after controlling for the beta, firm size, and January effects. Chan and Chen (1991), and Fama and French (1992) provided the same result as Bhandari. Moreover, Cheung and NG (1992) found that the conditional future volatility of stock returns is negatively related to stock prices after controlling for the effects of bid-ask spreads and trading volume. Black (1976) gave this relationship between the future volatility of stock returns and its prices the following explanation: a fall in a security's price value relative to the market value of its debt

[6] The MM theory means that the market value of an unlevered firm is equal to the observed market value of the firm less the present value of the Federal government tax subsidy for debt financing.

causes a rise in its debt to equity ratio and so increases its stock return volatility Such evidence suggests that we cannot rely on the single index model, like the CAPM, as a joint hypothesis in tests of financial market efficiency, nor can it be used as a sufficiently accurate vehicle for measuring portfolio performance Therefore, the objective of constructing a leveraged asset pricing model is to obtain a simple, testable model of stock market returns and to provide an insight into the main forces governing returns in the market

The theoretical work of Modigliani and Miller (MM, 1958), based on the homogeneous risk-class concept, plays an important role in constructing the LAPT Modigliani and Miller (1958) have already shown that under the no arbitrage condition and in the absence of taxes, the expected return of an asset is a linear function of its debt to equity ratio ("Proposition II") $R_l = r_t + \left(1 + \frac{D}{E}\right)[R_{t'} - r_t]$, where R_l is the return on the equity, r_t is the interest rate for the corporate debt The MM arbitrage result provides a stronger theoretical basis for model construction than the admittedly dubious assumptions underlying the CAPM It also shows that leverage is an important factor, that so far has not yet been identified separately in either the CAPM or the APT

In order to test the validity of the MM theory, Hamada (1972) employed three empirical tests to distinguish indirectly between the MM and traditional theories of corporation finance[7] He compared the standard deviation of β_U to the standard deviation of β_L by industries He utilise a chi-square test to test whether the distributions for β_L and β_U for each of the risk-classes followed the expected uniform distribution, and employed the analysis of variance (ANOVA) test to test whether the means of β_L or β_U between different industries were equal Consistently, these results showed that the MM theory is more comparable with the data that he investigated than the traditional theory

In the previous published literature, Hamada (1969),(1972) and Rubinstein (1973) assumed that returns on corporate debt are risk free and derived the Modigliani and Miller's (1958),(1963) capital structure proposition by using the mean-variance CAPM[8] This linkage gave Chance (1982) a means of bringing this partial equilibrium MM theory into the world of general equilibrium models via the notion of the market risk premium in the CAPM The simplified model was formally derived by Chance (1982) and the equation expressed as:

$$E[R_L] = R_f + \left[1 + (1-\tau)\frac{D}{E}\right]\beta_U\left[E[R_m] - R_f\right] \qquad (3\ 2)$$

where R_f is the risk free rate Although, Chance (1982) provided this modification of the CAPM, he chose to test the relationship of β_L and β_U using the market model The empirical results provided considerable support for the relationship $\beta_L = \left[1 + (1-\tau)\frac{D}{E}\right]\beta_U$

[7] The traditional theory means that the observed common stock's systematic risk, β_L, would be the same for all firms in a given risk-class regardless of differences in leverage, as long as the critical leverage point (this point is a function of gambler's ruin and bankruptcy costs) is not reached

[8] Conine (1980) extended Hamada's analysis by incorporating risky corporate debt into the levered beta relationship

3.6. Derivation of the LAPT

The CAPM is severely constrained in relating only to one factor, the returns on the market portfolio, which implicitly restricts the model to a single set of relationships with whatever underlying factors may explain returns on the market portfolio. However, the multi-factor APT seems more appropriate and, indeed, enjoys stronger empirical support.[9] Let us assume that, in a perfect capital market, returns on the equities of an unlevered firm iU and an levered firm iL for time t can be linearly related to J-1 common factors:

$$R_{iUt} = \alpha_{iUt} + \beta_{1iUt}F_{1t} + \cdots\cdots + \beta_{(J-1)iUt}F_{(J-1)t} + \varepsilon_{iUt} \tag{3.3}$$

$$R_{iLt} = \alpha_{iLt} + \beta_{1iLt}F_{1t} + \cdots\cdots + \beta_{(J-1)iLt}F_{(J-1)t} + \varepsilon_{iLt} \tag{3.4}$$

where subscript iUt represents the unlevered firm i at time t,

subscript iLt represents the levered asset i at time t,

F_i's are the factors which impact the return on levered and unlevered firm i,

α_i is the expected return for firm i if all the factors F_i's have values of zero,

β_{ji} is the sensitivity of firm i's return to the factor j,

and ε_i is a random zero mean noise term for firm i.

Taking the expected value of Equation (3.3) and subtracting it from Equation (3.3), we have

$$R_{iUt} = E[R_{iUt}] + \beta_{1iUt}[F_{1t} - E[F_{1t}]] + \cdots\cdots + \beta_{(J-1)iUt}\left[F_{(J-1)t} - E\left[F_{(J-1)t}\right]\right] + \varepsilon_{iUt} \tag{3.5}$$

[9] The APT is more general than a CAPM- type model, and the robustness of its construction compared with that of the CAPM has been discussed in section 2.2.3.

Assume that there are N securities in the equilibrium market and that N is sufficient so that portfolios which involve zero investment and have no risk must earn no return on average. These portfolios are called arbitrage portfolios. Mathematically, the zero investment can be written as

$$\sum_{i=1}^{N} X_i = 0 \tag{3.6}$$

where X_i is a proportion of an individual's total wealth invested in unlevered firm i, and no risk means

$$\sum_{i=1}^{N} X_i \beta_{1iUt} = 0$$

$$\vdots$$

$$\sum_{i=1}^{N} X_i \beta_{(J-1)iUt} = 0 \tag{3.7}$$

Then, from the arbitrage pricing theory, the arbitrage portfolio p satisfies conditions (3.6) and (3.7), and implies that

$$R_{pt} = \sum_{i=1}^{N} X_{it} R_{iUt}$$

$$= \sum_{i=1}^{N} X_{it} E[R_{iUt}] + \sum_{i=1}^{N} X_{it}\beta_{1iUt}\left[F_{1t} - E[F_{1t}]\right] + \cdots + \sum_{i=1}^{N} X_{it}\beta_{(J-1)iUt}\left[F_{(J-1)t} - E\left[F_{(J-1)t}\right]\right] + \sum_{i=1}^{N} X_{it}\varepsilon_{iUt} \tag{3.8}$$

Add the additional condition that, under the law of large numbers, the weighted average of the many error terms will approach zero:

$$\sum_{i=1}^{N} X_{it}\varepsilon_{iUt} \approx 0 \tag{3.9}$$

Equation (3 8) implies further that

$$\sum_{i=1}^{N} X_{it} E[R_{iUt}] = 0 \tag{3 10}$$

Now, according to a well-known theorem in linear algebra, if a vector X being orthogonal to J vectors implies it is orthogonal to a (J+1)'th vector, the (J+1)'th vector can be expressed as a linear combination of the J vectors. Therefore, Equations (3 6), (3 7), and (3 10) imply that there must exist coefficients, $\lambda_0, \lambda_1, \ldots, \lambda_{(J-1)}$ such that

$$E[R_{iUt}] = \lambda_{0t} + \lambda_{1t}\beta_{1iUt} + \cdots\cdots + \lambda_{(J-1)t}\beta_{(J-1)iUt}$$

If riskless lending and borrowing rates of return, R_f, exist, then, for a riskless asset, all the sensitivities of the returns $\beta_{1iUt} = \cdots = \beta_{(J-1)iUt} = 0$, therefore, $\lambda_{0t} = R_{ft}$

Hence,

$$E[R_{iUt}] = R_{ft} + \lambda_{1t}\beta_{1iUt} + \cdots\cdots + \lambda_{(J-1)t}\beta_{(J-1)iUt} \tag{3 11}$$

We now assume that there is another levered firm iL, which generates the same stream of operating income as the unlevered firm iU but is partly financed by debt. From Modigliani and Miller's (MM) Proposition II[10] (which is revised under

[10] The original Modigliani and Miller's (MM) theories of capital structure are built under the US classical tax system. The classical tax system requires equity income to be taxed at both the corporate and the personal levels (double taxation of dividend), and it favours debt finance as interest is taxed only at the personal level. We know that the U.K. tax system is sufficiently different from the U.S. tax system, that means using the original MM theories of capital structure to explain the UK economy is meaningless. There are some researchers, like Stapleton and Burke (1975), (1977), Edwards (1984), Mayer (1986), and Ashton (1989a), (1989b), (1991) devoted to studying the various features of the UK tax system which reduce the influences of taxation on corporate financial policy. Based on the current UK Imputation Tax System (part of the company's tax bill is regarded as a credit against the shareholders' income tax liabilities on dividends if company has paid tax), Ashton (1991) argued that "unlike the US system of taxation, the UK system of taxation in general favours rather than discriminates against dividends". He, then, suggested a modified MM Proposition II (equation (3 12)), with the assumptions of the existence of a Miller (1977) equilibrium (the supply of corporate debt is in equilibrium with the demand for debt) and of the irrelevancy of dividend policy, which may be more appropriate in explaining the UK economy.

current U K tax legislation) the relationship between the levered, R_{dt} , and unlevered returns, R_{dUt}, to equity is as in equation (3 12)

$$E[R_{dt}] = r_t(1-\tau) + L_{d,t-1}\left[E[R_{dUt}] - r_t(1-\tau)\right] \tag{3 12}$$

where r_t is the gross interest rate on the corporation debt It is assumed that debt is risk free,

τ is the corporation tax,

the leverage factor, $L_{d,t-1}$, equals $\dfrac{(E_{dL,t-1} + D_{dL,t-1})}{E_{dL,t-1}}$,

$E_{dL,t-1}$ and $D_{dL,t-1}$ are respectively the market values of the equity and the debt financing for the levered firm at time t-1

Recently, there have been some financial studies by Fuller and Kerr (1981), Conine and Tamarkin (1985), and Butler, Rosanne, and Simonds (1991) empirically examining the effects of the Hamada (1972, $\beta_L = \beta_U\left[1+(1-\tau)\dfrac{D}{E}\right]$) and the Conine (1980, $\beta_L = \beta_U\left[1+(1-\tau)\dfrac{D}{E}\right] - \beta_{Debt}\left[(1-\tau)\dfrac{D}{E}\right]$) leverage adjustments on the systematic risk for multisegment firms (if corporate debt is risk free, the Conine leverage adjustment is the same as the Hamada leverage adjustment) Consistently, the results of these studies showed that the two leverage-adjusted betas (Hamada's (1972) and Conine's (1980)) did not exhibit better ability to explain and predict security returns Perhaps these unexpected results are due to the fact that they seem to use the leverage data at time t rather than that at time t-1 to examine the predictive ability of the two leverage-adjusted betas as L_{t-1} denotes the leverage data at the beginning of the period t (see page 438 in Hamada (1972))

Now, substituting (3.11) into (3.12) and assuming that the risk-free interest rate exists, we obtain the Leveraged Asset Pricing Theory (LAPT):

$$E[R_{it}] = R_{ft}(1-\tau) + L_{i,t-1}\left[R_{ft} + \lambda_{1t}\beta_{1iUt} + \cdots + \lambda_{(J-1)t}\beta_{(J-1)iUt} - R_{ft}(1-\tau)\right]$$

$$= R_{ft}(1-\tau) + L_{i,t-1}\beta_{1iUt}\lambda_{1t} + \cdots + L_{i,t-1}\beta_{(J-1)iUt}\lambda_{(J-1)t} + L_{i,t-1}R_{ft}\tau$$

$$= R_{ft}(1-\tau + L_{i,t-1}\tau) + L_{i,t-1}\beta_{1iUt}\lambda_{1t} + \cdots + L_{i,t-1}\beta_{(J-1)iUt}\lambda_{(J-1)t} \qquad (3.13)$$

where λ_j represents the risk premium for the jth factor and is the expected excess return on a portfolio with $L_{i,t-1}\beta_{jiUt}$ equal to one on the jth index of equation (3.13) if the formula representing what we have called the Leveraged Asset Pricing Theory.

3.7. Properties of the LAPT

The Leveraged Asset Pricing Theory (LAPT) is an MM valuation model. It is constructed by relating returns on unlevered assets, R_{Uit}, obtained from a multi-factor Arbitrage Pricing model, to an unlevered systematic risk measure, β_{iU}. Then substituting this equilibrium equation into the modified MM Proposition II, the relationship between the common shareholder's rate of return, R_i, and the leverage factor is obtained. The principal assumptions for constructing the LAPT are that the Arbitrage Pricing model and the MM proposition II holds in every time period in a perfect capital market. Comparing expressions (3.4) and (3.13), the same decomposition of the firm's market-based beta, $\beta_{iLt} = \left(1 + \frac{D_{i,t-1}}{E_{i,t-1}}\right)\beta_{iUt}$, was obtained as in Hamada's analysis (1972, expression (4a)). It is evident that the firm's market-based beta, β_{iLt}, is divided into two components: (1) a financial leverage component, $(1 + D_{i,t-1}/E_{i,t-1})$, and (2) an operating or a business risk component β_{iUt}[11]. This separation is implied by Modigliani and Miller's (1958),(1963) leverage irrelevance result.

An advantage of the LAPT is that it allows the changes in the underlying leverage variable $\left(\frac{E_{i,t-1} + D_{i,t-1}}{E_{i,t-1}}\right)$ of each company at time t-1 to have an immediate impact on its beta estimated at time t. The structure of the LAPT makes explicit the leverage factor which is implicit in the CAPM and the APT, this means that the effect of the time-varying character of leverage on returns can be incorporated more accurately in the model.

3.8. End Notes

This chapter started a brief review of the existing literature concerning beta estimations, such as historical and fundamental betas, in order to have some idea of

[11] Ross (1985) examined the theoretical relationship between the firm's operating risk and debt policy, and demonstrated an inverse relationship between the ordinary measure of risk (β_u) and financial leverage (1+D/E) in a cross-section of firms. The intuition underlying this result is that, given the total risk is constant, increasing operating beta raises the expected return and, therefore, lowers the value of debt. Further, Chung (1989b) assumed that if the end-of-period cash flows follow a normal distribution and the debt obligation, including principal and interest expense, is constant, then this inverse relationship between the risk and financial leverage that Ross (1985) raised becomes easier to be empirically tested.

their characteristics Then, an alternative model, the Leveraged Asset Pricing Theory (LAPT) which unifies the Arbitrage Pricing Theory and Modigliani and Miller Proposition II of capital structure, was derived and its properties were described

In the next chapter, I will record the data sources and methodology of the empirical tests for comparing the predictive ability of the five various models

CHAPTER 4

THE PREDICTIVE ABILITY OF THE VARIOUS MODELS: EMPIRICAL METHODOLOGY

4.1. Introduction

In this chapter, I conduct an empirical study comparing the predictive ability of five different models (the naive market return, the market model, the CAPM, the APT, and the LAPT), and comparing also two different parameter adjustments of the discount weighted estimation method (DWE) --(i) filtering and (ii) combined filtering and smoothing. This chapter describes predictive experimental procedures which are designed to examine the ability of some operationalised models with different beta estimates (or systematic risks) to predict U.K. equity returns.

This chapter is organised as follows. Section 4.2. introduces two extensions to improve parameter estimation in U.K. stock market empirical research. One is the nontrading effect, the other is variations in parameters. Section 4.3. describes data sources and the definitions of each variable which will be employed in the study. Finally, the empirical methodology to test the predictive ability of the five different models is documented in section 4.4.

4.2. Improvements of the Empirical Estimation Procedures

Two methods of reducing parameter estimation biases are employed in this U K stock market empirical research -- (i) the nontrading effect, and (ii) variations in parameters After comparing three approaches to correcting the bias in beta estimates induced by nontrading, the Trade-to-Trade (TT) method is proposed to correct the nontrading problem Problems of variations in parameters are relieved by using the Discount Weighted Estimation (DWE) method

4.2.1. Nontrading Effect

A well-known practical problem which was recognised first by Fama (1965) and Fisher (1966) is the phenomenon of nontrading of securities Its impact was ignored for several years until comprehensive stock exchange databases became available for empirical researchers For example, Scholes and Williams (1977), Dimson (1979), Fowler, Rorke, and Jog (1979), Hawawini and Michel (1979), Fung, Schwartz, and Whitcomb (1985), and Berglund and Liljeblom (1986) studied U S , U K , Canadian, Belgian, French, and Finnish data, respectively To sum up these researchers' findings, there are three major sources of bias reflecting the nontrading problem for empirical studies of stock prices They are (a) thinness of trading, (b) unreported transactions, and (c) nonsynchronous trading In sum, a stock price recorded at the end of a time period in databases represents the outcome of a transaction which might actually have occurred earlier or was unreported in the time period Fisher (1966) pointed out that these cause an index constructed from such nonsynchronous stock price data to be positively serially correlated and the estimated variance of the index to be downward biased[1] The nontrading effect is thus also known as the "Fisher effect[2]"

The market model is a conventional model for forming benchmark expected returns,

$$R_i = \alpha_i + \beta_i R_m + \varepsilon \quad ,$$

where α_i is the component of security $i's$ return which is independent of the market's performance, β_i is the covariance of security $i's$ return with the market return divides the variance of the market return, and ε is the random error term Failure to adjust for nontrading will introduce the following biases:

(a) time series of stock returns are autocorrelated[3]

Scholes and Williams (1977) demonstrated that in the plausible special case with nontrading periods distributed independently and identically over time, measured autocorrelations of lag-one which depend on real observations for single securities appear negative

(b) variances for individual securities are overstated

With nontrading periods distributed independently and identically over time, Scholes and Williams (1977) showed that measured variances overstate true, unobservable variances.

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[1] Dimson (1979), and Marsh(1979).

[2] Errors in security returns will not cause biases of the parameter estimates unless they are correlated with the market returns Thus, other sources of bias associated with nontrading include movements across the buy/sell spread and data measurement errors, e.g. price rounding, are unavoidable when these errors are unidentifiable in databases

[3] Fama, Fisher, Jensen, and Roll (1969), Schwartz and Whitcomb (1977a), and Cohen, Maier, Schwartz, and Whitcomb (1979)

(c) covariances between share returns and the market index are substantially underestimated

With the same assumption for the nontrading periods, Scholes and Williams (1977) showed that the covariance between returns of a security and the market index underestimates the covariance between the true returns of the security and the true market index (equation (A8) in the Appendix (iii) of their paper)

(d) distributions of security returns deviate from normality[4]

Under the assumption that the distribution of nontrading periods is stationary, Scholes and Williams (1977) showed that the distributions of measured daily returns for single securities appear leptokurtic relative to true returns

(e) misspecification of the parameters alpha and beta[5]

Scholes and Williams (1977) and Dimson and Marsh (1983) demonstrated that the directions of the biases in the estimates of alpha and beta are indeterminate and will depend both on the relative trading periods of the shares in the sample and on the constituents of the market index. However, when shares are thinly traded and when the market index suffers from thin trading, their alpha estimates are usually biased upwards and beta estimates biased downwards on the market model

(f) the interval effect

Altman, Jacquillat, and Levasseur (1974), and Pogue and Solnik (1974) found that in the market model R^2 falls as the differencing interval is shortened. Schwartz and Whitcomb (1977a) demonstrated that the definition of the coefficient of determination, R^2, of the market model implies that when stocks are thinly traded there are induced negative residual autocorrelations and positive market returns autocorrelations.

[4] French, Schwert, and Stambaugh (1987), and Lau, Wingender and Lau (1990).

[5] Ball (1977)

Therefore, the mechanism causes R^2 to decrease as the differencing interval is decreased Moreover, Lo and Mackinlay's (1990) empirical work demonstrated empirically that as the differencing interval is shortened, the expected return is smaller Therefore, according to their stochastic model of nonsynchronous asset prices, the extent of overestimation of return variance is smaller and negative autocorrelation in individual security returns is close to zero

(g) the variation explained by market movements, R^2, will be low, and the regression exhibits heteroscedasticity

Although the last bias is not theoretically supported, Fowler, Rorke, and Jog (1979) classified data into four categories based on trading frequency and investigated the relationships between nontrading and R^2 and between nontrading and heteroscedasticity, with data from the Toronto Stock Exchange (TSE) They found that thinly traded securities reveal low R^2 and heteroscedasticity

Further evidence from Fowler, Rorke, and Riding (1979) and Schwartz and Whitcomb (1977b) indicates that using thinly traded data introduces positive autocorrelation in the independent variable and negative autocorrelation in the dependent variable, so that regression estimates of alpha and beta may be biased and inconsistent, therefore the market model R^2 will be caused to fall and the regression may exhibit heteroscedasticity

The nontrading problem not only introduces the biases mentioned above but also can introduce a false degree of stability in the estimates if trading infrequency is relatively constant through time This econometric problem was addressed by Dimson and Marsh (1983) when they clarified the earlier puzzling discovery (e g Altman, Jaquillat, and Levasseur (1974) on French data, Hawawini and Michel (1979) on Belgian data, and Korhonen (1976) on Finnish data) that betas for small stock markets, appear to be at least or even more stable than betas estimated on U S NYSE data

Several methods and alternatives have been proposed to correct for the bias in beta estimates produced by nontrading There are three notable approaches -- the lagged market returns method, the Aggregated Coefficients (AC) method, and the Trade-to-Trade method However, none of these approaches is suitable for general application Each of them is valuable in particular circumstances dependent on the content and characteristics of the employed database Through the following introductions and comparisons, the Trade-to-Trade method which is applicable to the U K database will be suggested

There exists some corrective alternatives, e g Pogue and Solnik (1974), Ibbotson (1975), Schwert (1977), and Theobald (1980), which regress individual security returns on synchronous and nonsynchronous market returns Scholes and Williams (1977) made an assumption that nontrading periods are distributed independently and identically over time They demonstrated a computationally convenient, consistent beta estimator, $\hat{\beta} = \frac{b_{t-1} + b_t + b_{t+1}}{1 + 2\hat{\rho}_M}$, where b_{t-1}, b_t , and b_{t+1}, respectively, represent the ordinary least squares lag-one, synchronous, and lead-one beta estimators, and $\hat{\rho}_M$ represents the estimated lag-one autocorrelation coefficient of the market returns All these four estimators (b_{t-1}, b_t , b_{t+1}, and $\hat{\rho}_M$) are biased and inconsistent as well The advantage of the Scholes-Williams method is that the beta estimator, $\hat{\beta}$, can be easily calculated from available data The beta estimator doesn't depend on detailed assumptions for nontrading time periods, it requires only an independently and identically distributed sequence of nontrading periods The interval effect can be taken into account because of the existence of $\hat{\rho}_M$ (empirical evidence shows that $\hat{\rho}_M$ tends to approach zero as the differencing interval is lengthened) Although the beta estimator adjusted by the Scholes and Williams method is consistent, it is unbiased only under the assumption that nontrading periods are an independently and identically distributed sequence However, Dimson (1979) identified some situations where the Scholes-Williams method would be inappropriate For example, if share prices do not exist or are not followed by a trade in an immediately adjacent time period, this approach may fail to make use of them In Scholes and Williams's (1977) empirical study, a return is calculated and used only if three consecutive transactions are known The market index is defined to be the mean of all such returns These procedures reduce the sample size and may also bias the beta estimation

A development of the lagged market returns approach was suggested by Dimson (1979) He assumed that the distributions of both (i) the probability that a security had been traded at a time point in a period and (ii) the proportions of the market portfolio that was traded at a time point in a period were stationary and identically distributed over time He then regressed the returns of a stock on the lagged, synchronous, and leading returns on the market index A consistent estimate of beta is obtained simply by summing up the coefficients, e g $\hat{\beta}_i = \sum_{s=-N}^{N} \hat{\beta}_{i,s}$ This alternative for estimating betas is called the Aggregated Coefficients (AC) method The AC method doesn't require a return to be continuously traded Dimson (1979) pointed out that the AC estimator generally remained more efficient than the Scholes-Williams estimator It is understandable that the more independent variables a regression introduces, the smaller the variance of the beta estimate becomes However, the appropriate number of leads and lags to include in a multiple regression of security returns are variable, which may introduce bias to the beta of severely nontraded securities since their returns and market returns may be autocorrelated

Another analogue of the Dimson's AC method is the Cohen, Hawiwini, Mayer, Schwartz, and Withcomb (CHMSW, 1983) method This method relaxes the assumptions that Scholes and Williams (1977) made for obtaining estimators of beta in the presence of thin trading and assumed only that the delayed market returns are stationary and independent, and it still maintains the advantages of both Scholes and Williams's method and the AC method discussed in this section

A better alternative which abandons the use of equal length periods, and takes the actual timing of trades into account instead, is the trade-to-trade method With this method, beta is measured by regressing returns calculated between adjacent recorded trades on the market returns which are calculated over precisely the same time intervals The Trade-to-Trade method is not applicable unless transaction dates of all share prices and continuously recorded market returns are available In view of the onerous data demands, this procedure only appears so far to have been used in analysing U K and Finnish stock where appropriate data exists[6] When feasible , the trade-to-trade method will produce more accurate estimates than other methods This can correct for the thin trading bias, as indicated by the empirical results of Dimson (1979) Additionally, because it allows beta estimates to have flexible length periods, missing returns can be handled and the sample size can be maintained

Since the London Stock Price Database (LSPD) became available, the nontrading problem has attracted much attention as it is indeed a serious problem In an analysis of the age of the transaction prices recorded for the LSPD random sample from 1955 to 1974, Dimson (1979) found that in the most infrequently traded decile portfolio, for about a third of companies recorded prices are on average more than fifty days out of date Fortunately, this problem had been anticipated in the construction of the LSPD The database records not only the last transaction price of the month, but also the age of each price in days from month end

Using the Trade-to-Trade method to correct the beta estimation is only likely to solve part of the problems caused by nontrading Recalling those approaches mentioned before, none of them can completely satisfy all the sources of bias in beta estimation Possibly, some combination of these methods could be cautiously used Dimson and Marsh (1983) showed that after using the Trade-to-Trade method which dramatically reduced thin trading bias, beta estimates were shown to be as stable in the U K as they were in the U S A Following Blume's (1975) procedure they found that,

[6] Franks, Broyles, and Hecht (1977), Dimson (1979), Marsh (1979), Dimson and Marsh (1983),(1984),(1986), and Fong (1992) used U K data, and Berglund, Liljeblom, and Loflund (1989) used Finnish data

U K Trade-to-Trade beta estimates still appeared to regress towards their mean However, after a sequence of investigations, Dimson and Marsh suggested that Blume's Bayesian adjustment is effective in pulling the estimates in towards the mean This improved the Trade-to-Trade betas as predictors of subsequent period betas

In consequence, I propose to use the Trade-to-Trade method in the empirical work The Trade-to-Trade betas will be Bayesian-adjusted to correct for the regression tendencies of betas, as will be described in next section

4.2.2 Variations in Parameters

Much research on modelling the behaviour of stock return or volatility assumes that parameters of models are constant over time This assumption is violated in the real world as we have already known A conventional estimation method, the Kalman Filter technique, which permits variations in parameters and has many applications in economics and finance particularly in empirical work In fact, this method essentially is equivalent to Bayesian Forecasting From a paragragh quoted in West and Harrison's book, "*Bayesian Forecasting and Dynamic Models*":

"At about the same time in 1969, it became clear that some of the mathematical models were similar to those used in engineering control It is now well-known that, in normal Dynamic Linear Models with known variances, the recurrence relationships for sequential updating of posterior distributions are essentially equivalent to the Kalman Filter equations, based on the early work of Kalman (1960), (1963) in engineering control, using a minimum variance approach It was clearly not, as many people appear to believe, that Bayesian Forecasting is founded upon Kalman Filtering (see Harrison and Stevens, 1976a, and discussion, and reply to the discussion by Davis of West, Harrison and Migon, 1985) To say that "Bayesian Forecasting is Kalman Filtering is akin to saying that statistical inference is regressions!" (1989, p35)

we know that Bayesian Forecasting is broader and more flexible than Kalman Filtering

In this thesis, one of the estimation methods, the Discount Weighted Estimation (DWE) method based on Bayesian adjustment, has been chosen to estimate and to smooth changing parameters (Simple examples of applying the Discount Weighted Estimation Filtering method can be found in Harrison and Johnston (1984), Ameen and Harrison (1983), (1984), or West and Harrison (1989)) Ameen and Harrison (1984) based Discount Weighted Estimation upon the discount concept that the information content of an observation decays with its age The DWE allows different model components to have different discount weights as there might be numerous characteristics in a system Explicitly, it generalises the Exponentially Weighted Regression (EWR) which simply depends upon one discount factor The DWE technique enables us to estimate and forecast random processes which evolve linearly and are observed subject to noise The method produces recurrence relationships for the sequential updating of the regression parameters and of the variance, and is used not only to forecast but also to smooth the time series of parameters The advantages of using this method are that (1) distinct model components (if there are k independent variables, there will be k discount weights for k parameters) are allowed to have different associated discount weights (for predicting future data, the most recent data are thought more important than the older data), (2) the error term does not need to be homoskedastic, (3) the availability of a large quantity of historical data is not required, and (4) inverting a correlation matrix is not involved (problems can arise when the independent variables are correlated). Moreover, in empirical work, practitioners have difficulty in specifying a system variance matrix W. But the use of discount factors, δ, in DWE overcomes the major disadvantages of having to give the values of W, since a discount factor converts its component posterior precision C_{t-1} at time $t-1$ to a prior precision $R_t = \frac{1}{\delta}C_{t-1}$ for time t (see Appendix A).

The detailed derivations of the Discount Weighted Estimation (DWE) method appear in Appendix A. DWE can be applied in two ways: (i) filtering, and (ii) combined filtering and smoothing. I first discuss filtering and then combined filtering and smoothing.

Assuming that there are k parameters in a Dynamic Linear model that need to be estimated, and given the information available at time t-1, D_{t-1}, the kx1 vector of filtered beta prior estimates is exactly the same as the kx1 vector of posterior betas:

$$E[\beta_t|D_{t-1}] = E[\beta_{t-1}|D_{t-1}] = E[\beta_{t-1}|D_{t-2}] + A_{t-1}\left(Y_{t-1} - F_{t-1}'E[\beta_{t-1}|D_{t-2}]\right)$$

$$= E[\beta_{t-1}|D_{t-2}] + A_{t-1}e_{t-1},$$

where D_{t-1} represents the information available at time t-1. It includes both the previous information set D_{t-2} and the observation Y_{t-1},

e_{t-1} is the scalar one-step ahead forecast error. It is the difference between the observed value of Y_{t-1} and the expected value of Y_{t-1},

A_{t-1}, the kx1 vector of adaptive coefficients, is the kx1 vector of prior regression coefficients ($E[\beta_{t-1}|D_{t-2}]$) upon Y_{t-1}, and $0 \le a_{t-1} \le 1$, a_{t-1} is any one of the elements in vector A_{t-1},

Y_{t-1} is the dependent scalar variable at time t-1,

F_t is the kx1 vector of independent variables at time t-1,

and $E[\beta_{t-1}|D_{t-2}]$ is the kx1 vector of regression parameters at time t-1 given the information available at time t-1

If the weight, A_{t-1}, is close to zero then $E[\beta_{t-1}|D_{t-1}] \approx E[\beta_{t-1}|D_{t-2}]$ and none of the changes in the time series will be captured by the predictor of Y_{t-1}. That is to say, the larger the value of A_{t-1}, the more sensitive is the predictor $F'_{t-1}E[\beta_{t-1}|D_{t-2}]$ to the latest values of the observation series Y_{t-1} [7]

Another alternative which takes the information available after time t into account is called the smoothed time series. For $s \ge 1$, the s-step smoothed beta estimates is obtained from

$$E[\beta_t|D_{t+s}] = (1 - \frac{1}{\Delta\Delta})E[\beta_t|D_t] + \frac{1}{\Delta\Delta}E[\beta_{t+1}|D_{t+s}]$$

$$\Delta = diag\left[1/\sqrt{\delta_1}, 1/\sqrt{\delta_2}, \cdots\cdots\cdots, 1/\sqrt{\delta_k}\right],$$

where Δ is the kxk matrix of discount factors (δ_k) for the variances of k beta estimates,

$\Delta\Delta$ is the product of the kxk matrix of Δ,

[7] Simple examples of applying the Discount Weighted Estimation Filtering method can be referred to Harrison and Johnson (1984), or West and Harrison (1989).

$\beta_t|D_{t+s}$ is the kx1 vector of beta estimates at time t given the information available for s time points after time t

Given the information available for s-1 time points after time t+1, this smoothing procedure consists of taking a weighted average of the posterior beta estimates at time t, $\beta_t|D_t$, and the smoothed beta estimates at time t+1, $\beta_{t+1}|D_{t+s}$. It depends on the discount factors which control the magnitude of variance of beta estimates. That is, the larger the discount factors, the smaller the magnitude of the changes in the variance. Therefore, the smoothing procedure puts more weights on future beta estimates. On the other hand, the smaller the discount factors, the larger the magnitude of the changes in the variance. Therefore, the smoothing procedure puts more weight on current beta estimates.

4.3. Empirical Data Description

The sample for this study was taken as the overlap between the sample of Datastream[8] U.K. company long-term liability data, and the LSPD[9] return sample from 1976 to 1990. This reduced the sample available for these time series empirical tests to 172 companies.

---

[8] Datastream contains numeric information. The information relates to: (1) Company financial information from the annual report of UK quoted companies and a selection of overseas quoted companies. Information on UK companies dates back to 1968, where available. (2) Stock market information. (3) Economics and business statistics.

[9] The London Share Price Database (LSPD) contains several different samples, e.g. a random sample of 33% of the companies (by market value) quoted on the London Stock Exchange in January 1955 together with 33% of new issues in each year. Since 1975, there is a complete history for all U.K. companies quoted in London, including those companies traded on the USM. There is no survivorship bias in the LSPD after 1975.

In order to reduce the bias from nontrading, the Trade-to-Trade (TT) method, which defines periods in terms of the timing of the most recent actual trades, was used for estimating risk measures Thus, returns on securities are calculated on the basis of those trades nearest the month ends, and the market returns are then measured on the same dates and over the same calendar period A daily index of market returns is required It is defined as follows in Datastream

$$RI_t = RI_{t-1} * \frac{PI_t + XDchange * f}{PI_{t-1}}$$

where RI_t is the broadly-based, capitalisation weighted Financial Times-Actuaries all-share return index (FTA)[10] on day t The calculation of the return index is based on the re-investment of gross dividends and so ignores tax and re-investment charges,

PI_t is the Financial Times Actuaries All-share price index on day t,

$XDchange$ is the ex-dividend adjustment (XD)[11],

f is the grossing factor (normally 1), if dividend yield is a net figure rather than gross f is used to gross up the yield,

Then, monthly market return, R_{ms_i}, over the same calendar period, $[s_i, (s-1)_i]$, of monthly return, R_{is_i}, for security i is measured as the formula

$$R_{ms_i} = \ln\left(\frac{RI_{s_i}}{RI_{(s-1)_i}}\right) = \ln\left(\frac{PI_{s_i} + XDchange * f}{PI_{(s-1)_i}}\right)$$

[10] The FTA is a market-value weighted arithmetic index covering 750 larger U.K. companies Unlike the London Share Price Database (LSPD) returns file, the FTA All Share Index excludes commodity companies, e.g. rubber, teas, coppers, mining and tins, and investment trusts Details about the FTA index see "Guide to FT statistics" published by the *Financial Times*.

[11] When a share goes ex-dividend, the price of the share will drop by an amount corresponding to the dividend paid (all else being equal). In the UK under the imputation tax system tax effects on this ex-dividend adjustment would be expected to be less than under the classical tax system

The leverage variable theoretically is based on market value measures of debt and equity Determining the market value of debt may seem straight forward but is troublesome as most of the events of debt cannot be valued so easily at market value However, using different procedures to estimate the market value of debt, most empirical researchers found that book value measures provided better leverage-adjusted beta estimates For example, Hamada (1972) showed that market values of equity and debt change dramatically as security prices rise and fall over time Fuller and Kerr (1981) calculated both market and book value measures of debt and equity, finding that leverage adjustments based on book values of equity and debt worked better than those based on market values of equity and debt as they presumed that book values are more stable Through careful evaluation of variables, Bowman (1980) compared the empirical applicability between the book-value and market-value measures of leverage in explaining systematic risk He concluded that a mixed measure of book-value debt and market-value equity was the most closely associated with the firm's market risk Although Mulford (1985) indicated that employing book values as proxies for market values of debt and equity may become a severe problem in financial empirical research during periods of extreme volatility in interest rates, the book-value of debt was still used in his study Considering the high correlation between market-value and book-value measures of debt demonstrated by Bowman (1980), the considerable costs of estimating the market values of the variety of debt instruments employed by the many companies in the sample does not appear worthwhile at this preliminary stage of testing a new model

According to these considerations, the market value of common stockholders' equity, E, was measured as equity market value per share of common stock times the number of common shares outstanding and was adjusted every month. The D of this study was measured as the book value of long-term liabilities[12] obtained from the Datastream company accounts data and was adjusted each year. Therefore, the research sample was constrained in those companies for which the debt data was available.

4.4. Empirical Research Methodology

The purposes of this empirical study are to compare the predictive ability of five different models (the naive market return, the market model, the CAPM, the APT, and the LAPT). The market model and the CAPM are evaluated under two different parameter adjustments of the discount weighted estimation method (DWE) -- (i) filtering and (ii) combined filtering and smoothing discussed earlier. The constant individual-asset factor loadings for the APT and the constant individual-unlevered-asset factor loadings for the LAPT are estimated by using the factor analysis.

To test the predictive ability of the different models, the realised security return, $R_{il,t}$, was compared to five appropriate benchmark expected returns, $E[R_{il,t}]$. The null hypothesis is that the actual return and the expected return are not significantly different (i.e. that the residual, $e_{il,t}$, is not significantly different from zero).

[12]This includes preference capital and total loan capital. Total loan capital relates to all loans repayable in more than 1 year. Loans from group companies and associates are included.

$$H_o : e_{iLt} = R_{iLt} - E[R_{iLt}] = 0$$

Actual security returns were taken from the LSPD monthly returns file from January 1976 to December 1990. The monthly series of dividend adjusted logarithmic returns are calculated as

$$R_t = \ln\left(\frac{P_t + d_t}{P_{t-1}}\right).$$

where P_t is the last traded price in the month if the transaction is not on the last day of the month.

d_t is the dividend declared ex-div during month t adjusted for any capital changes during the month.

P_{t-1} is the last traded price in month t-1.

The five types of benchmark expected returns are:

(I) a naive forecast equal to the market return

$$E[R_{iLt}] = R_{mt};$$

where R_{mt} is the Trade-to-Trade capitalisation weighted Financial Times Actuaries (FTA) all-share market index.

(II) forecast returns of the market model

$$E[R_{iLt}] = \alpha_{iLt} + {}_{MM}\beta_{it} R_{mt};$$

Because the Trade-to-Trade (TT) method directly abandons the use of equal length periods and takes the actual timing of trades into account instead, estimating parameters might induce heteroscedasticity in the residuals as each return datum might not cover an equal length period of time. Of course, the return variation is expected to increase with the length of the time period for the return. To ensure that the Trade-to-Trade beta estimates are efficient as well as unbiased, Marsh (1979) proposed a weighting scheme[13] to avoid heteroscedasticity in the residual if beta is estimated by using ordinary least squares. The transformed regression becomes

$$R_{it_i} / \sqrt{d_{it_i}} = \alpha_{it_i} / \sqrt{d_{t_i}} + \beta_{it_i} R_{mt_i} / \sqrt{d_{t_i}} \quad ,$$

where d_{it_i} is the length of the period $\left[(t-1)_i, t_i\right]$ for company i between two adjacent trades. (When the expected return is compared with the actual return, the transformed expected return was converted to the originally expected return by multiplying by the square root of the elapsed time.) In addition to correcting for the problems of nontrading, the Discount Weighted Estimation Method was used to avoid the problems of variations in parameters. The parameters $\alpha_{i,t}$ and $\beta_{i,t}$ were estimated by two adjustment methods. One is simply by filtering from the previous five years' LSPD return data, the other is by both filtering from the previous five years and smoothing back from the time five years after time t.

(III) forecast returns of the Capital Asset Pricing Model (CAPM)

$$E[R_{i,t}] = R_{ft} + {}_{CAPM}\beta_{it}\left(R_{mt} - R_{ft}\right);$$

where R_{ft} is the risk-free rate, taken as the three-month Treasury Bill rate, and the trade-to-trade capitalisation weighted Financial Time Actuaries (FTA) all-share market index was used as the proxy for the market. The method and procedure of estimating parameter ${}_{CAPM}\beta_{it}$ are the same as those described for the market model.

[13] Marsh (1979) assumed the variance of the residuals is approximately proportional to the length of the period.

(IV) forecast returns of the Arbitrage Pricing Theory (APT)

$$E[R_{it}] = R_{ft} + {}_{APT}\beta_{1i}\lambda_{1t} + \cdots\cdots + {}_{APT}\beta_{(J-1)i}\lambda_{(J-1)t}$$

The constant sensitivities, ${}_{APT}\beta_i$, of asset $i's$ monthly return to the factors were obtained from factor analysis using all stocks that were continuously listed during the ten-year period, Jan 1979 ~ Dec 1988 Then, these individual-asset factor loading estimates were used to estimate the risk premiums, λ, associated with the estimated factors, and the procedure is similar to a cross-sectional generalised least squares regression

(V) forecast returns of the Leveraged Asset Pricing Theory (LAPT)

$$E[R_{it}] = R_{ft} + L_{i,t-1} * {}_{LAPT}\beta_{1i(U)}\lambda_{1t} + \cdots\cdots + L_{i,t-1} * {}_{LAPT}\beta_{(J-1)i(U)}\lambda_{(J-1)t}$$

where ${}_{LAPT}\beta_{i(L)t} = L_{i,t-1} * {}_{LAPT}\beta_{i(U)} = \left(1 + \frac{D_{i,t-1}}{E_{i,t-1}}\right) {}_{LAPT}\beta_{i(U)}$ The method and procedure of estimating the individual-asset factor loadings, ${}_{LAPT}\beta_{i(U)}$, and risk premia, λ_t, associated with the estimated factors are the same as those mentioned in APT In the practice, $R_{it} - R_{ft}$ was used as the input data for extracting the factor loadings for the APT, where as $(R_{it} - R_{ft})\left(\frac{E_{i,t-1}}{E_{i,t-1} + D_{i,t-1}}\right)$ was used as the input data for extracting the factor loadings for the LAPT

4.5. End Note

In this chapter, the predictive experimental procedures were designed to examine the ability of five operationalised models -- the naive market index, the market model, the CAPM, the APT, and the LAPT -- in order to evaluate the quality of the new-derived LAPT Over the estimation procedures, the Trade-to-Trade method is proposed to avoid the problem of the nontrading effect, the Discount Weighted Estimation is chosen to estimate changing parameters for the market model and the CAPM, and the factor analysis is used to estimate the constant individual-asset factor loadings for the APT and the constant individual-unlevered-asset factor loadings for the LAPT Moreover, the sample data, and methodology used in this study of forecasting performance of the five models were described in detail as well

In the next chapter, I will report the results of this empirical work

CHAPTER 5

THE PREDICTIVE ABILITY OF THE LAPT: EMPIRICAL RESULTS

5.1. Introduction

This chapter reports the empirical results for comparing the predictive ability of the five different models (the naive market return, the market model, the CAPM, the APT, and the LAPT) described in the previous two chapters Section 5 2 provides summary statistics describing the characteristics of the beta estimates The comparisons of the predictive ability between the various models are described in section 5 3 The final section contains the research summary and conclusions

5.2 Characteristics of the Beta Estimates

Numbers describing features of the data are called descriptive statistics The two following sub-sections document means, standard deviations, and correlation coefficients of the various beta estimates These simple summary numbers will offer clues as to the general nature of the data

5.2.1. Descriptive Statistics of the Beta Estimates

Estimates of the factor loadings were produced by factor analysis There are some problems which are unique to factor analysis, for example, the signs of the factor loadings and the risk premia have no meaning (they could be reversed), the scaling of the factor loadings and the risk premia are free, etc Therefore, comparing the factor loadings with the betas of the market model and the CAPM would be meaningless

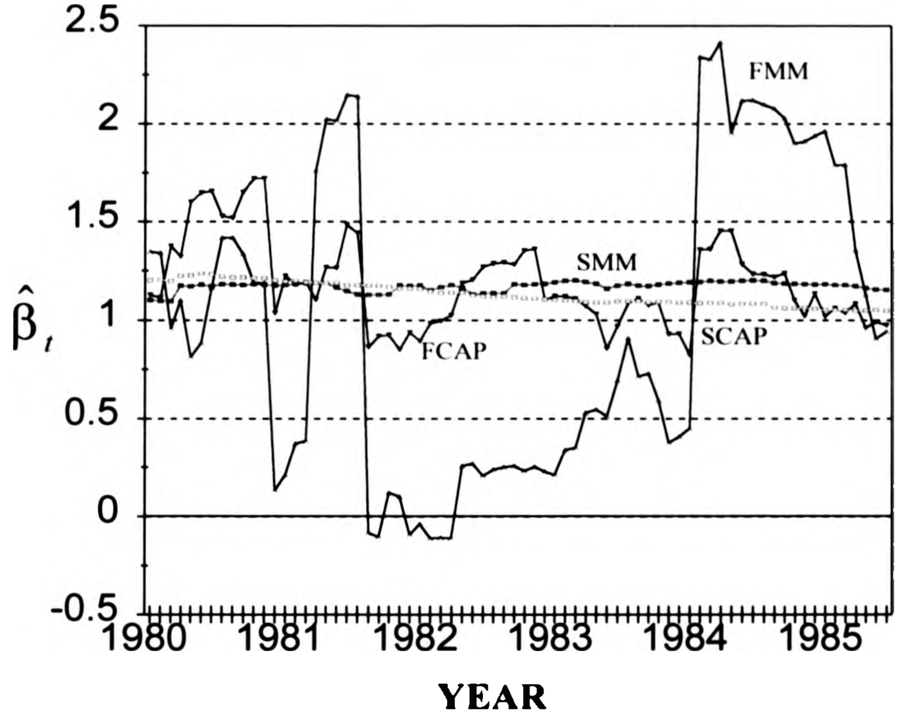
The starting point for the empirical analyses of beta estimates described in this chapter is the calculation of two characteristics of the beta estimates for the market model and the CAPM, the central tendency (mean) and the variability (standard deviation) Table 5 1 presents descriptive statistics and Figure 5 1 illustrates the behaviour of the various beta estimates for filtering, and for the combined filtering and smoothing estimation methods The descriptive statistics are summarised across the 172 firms (all beta estimates of the market model and the CAPM were updated monthly by using the DWE method The predictive tests were performed on a pooled sample (all firms) including cross-sectional time series data) Generally, based on the standard deviation over time, the betas estimated by the combined filtering and smoothing estimation method are more stable through time ($SD(\beta_{SMM})$ and $SD(\beta_{SCAPM})$ over time are 0.0634 and 0.0271, respectively) than those estimated

The Table 5.1. Descriptive Statistics of the Beta Estimates

	Filtering				Filtering and Smoothing		
	Mean	Standard Deviation Across Firms	Standard Deviation Over Time		Mean	Standard Deviation Across Firms	Standard Deviation Over Time
β_{FMM}	0.8818	0.3492	0.4411	β_{SMM}	0.8934	0.2604	0.0634
β_{FCAPM}	0.9842	0.1417	0.1798	β_{SCAPM}	0.9672	0.0968	0.0271

Note:- For case of expositions, the abbreviations used here are as follows:
FMM = Market Model in where parameters were estimated by using the Discount Weighted Filtering Estimation Method (DWFEM).
FCAPM = CAPM in where parameters were estimated by using the Discount Weighted Filtering Estimation Method (DWFEM).
SMM = Market Model in where parameters were estimated by using the Discount Weighted Smoothing Estimation Method (DWSEM)
SCAPM = CAPM in where parameters were estimated by using the Discount Weighted Smoothing Estimation Method (DWSEM).

Figure 5.1. The Behaviour of the Four Beta Estimates Over the 1980 to 1985 for the Firm -- B S G Itnl plc.



simply by the filtering estimation method alone ($SD(\beta_{FMMt})$ and $SD(\beta_{FCAPMt})$ over time are 0.4411 and 0.1798, respectively). It seems that this result succeeds in demonstrating the effectiveness of using a smoothing function since this is the function that the smoothing estimation method is designed to perform; that is, the combined filtering and smoothing estimates are based on more information than the filtering estimates. Therefore, they will have mean square errors (MSE) which, in general, are smaller than those of the filtering estimates. Also, the CAPM betas (β_{CAPMt}) are quite distinct from the market model betas (β_{MMt}) within the same estimation methods. They display higher mean value (close to one) ($E(\beta_{FCAPMt})$ and $E(\beta_{SCAPMt})$ are 0.9842 and 0 9672, respectively, whereas $E(\beta_{FMM})$ and $E(\beta_{SMM})$ are 0 8818 and 0 8934, respectively), and less variability ($SD(\beta_{FCAPM})$and $SD(\beta_{SCAPM})$ over time are 0 1798 and 0 0271, respectively, whereas $SD(\beta_{FMM})$ and $SD(\beta_{SMM})$ over time are 0 4411 and 0 0634, respectively)

5.2.2. Correlation Coefficients of the Beta Estimates

Table 5 2 presents the correlation coefficients between these various beta estimates for the sample of 172 U K companies Betas estimated by the filtering estimation method have hardly any correlation with those estimated by the combined filtering and smoothing estimation method for both the market model and the CAPM However, the correlation coefficients between the CAPM betas and the market model betas within the same estimation methods are roughly 40 percent and are larger when the combined filtering and smoothing estimation method is employed Relating the summary statistics described in Table 5 2 to Table 5 1., the results seem to imply that

Table 5 2 Correlations of the Beta Estimates

n=172	Correlation Matrix			
	β_{FMM}	β_{FCAPM}	β_{SMM}	β_{SCAPM}
β_{FMM}	-----------			
β_{FCAPM}	0 3616 (1 1111)	-----------		
β_{SMM}	0 1920 (0 4812)	0 0037 (0 0092)	-----------	
β_{SCAPM}	0 1167 (0 2893)	0 1977 (0 5418)	0 3970 (0 7374)	------------

Note: t-values appear in parentheses

any two beta estimates that possess closer standard deviations over time and that are estimated by same estimation method tend to have higher correlation

5.3. Comparisons of the Predictive Ability between Various Beta Estimates

In order to explore the predictive ability of these various beta estimates, observed security returns were compared to expected returns, and mean error (ME) and mean square error (MSE) were used to measure prediction bias and accuracy, respectively Figure 5 2 illustrates the theoretical relationship between prediction bias and prediction accuracy (Neter, Wasserman and Kutner (1985), p395)

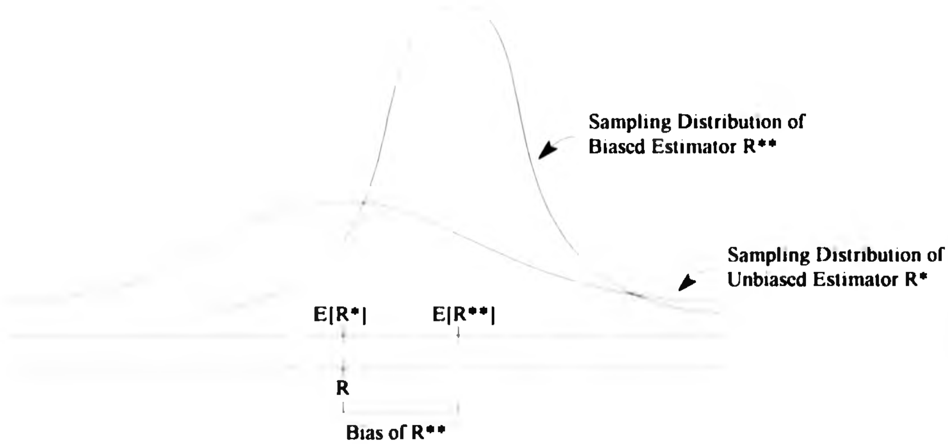


Figure 5 2 The Theoretical Relationship between Prediction Bias and Prediction Accuracy

When a return estimator, $E\left[R^{**}\right]$, has only a small bias and is substantially more precise (smaller variance) than an unbiased return estimator, $E\left[R^{*}\right]$, this biased return estimator may be a better return estimator since it will have greater probability of being close to the true return value. The measure of prediction accuracy, MSE, is the combined effect of bias (ME), inefficiency, and the unexplained random disturbance.

$$MSE = E\left[(R - E[R])^2\right] = (E[R - E[R]])^2 + (1-b)^2 VAR[E[R]] + (1-r)^2 VAR(R)$$

where b is the slope coefficient of the regression of R on $E[R]$, and r is the correlation of $E[R]$ and R. Thus, if the return estimator is unbiased, the MSE simply depends on the variances of the expected returns ($VAR[E(R)]$), the observed returns ($VAR[R]$), and the correlation between the actual returns and the predicted returns.

The adjusted coefficient of multiple determination (r_a^2) was employed to measure the proportionate reduction of total variation in observed returns (R) associated with the use of the set of independent variables. Its formula is defined as

$$r_a^2 = 1 - [(T-1)/(T-p)](SSE/SSTO)$$

where T is the time-series sample size,

p is the number of parameters need to be estimated,

SSE is error sum of squares, and

SSTO is total sum of squares.

The comparisons of the MEs, MSEs, and adjusted r_a^2 statistics between different models at the individual security level are presented in Table 5.3.

Generally speaking, average predictive ability of APT is slightly higher than other models. The APT(10) predictions in which factor loadings (constant over time) were obtained from the factor analysis using all stocks that were continuously listed during the ten-year period, Jan 1979 ~ Dec 1988, possess the best forecast accuracy (0.0078 which is not significantly different from zero), small bias (0.0004), and higher adjusted r_a^2 (0.3329). Although the LAPT(10) predictions have the highest adjusted r_a^2 (0.3910), they possess significant ME (0.0079) and MSE (0.0580) across firms. We will have a further look later comparing the APT and the LAPT.

Table 5.3 The Forecast Ability of the Return Predictions

Beta Estimates	All Firms ME	All Firms MSE	All Firms Adjusted r_a^2
$\beta_{MR} = 1$	0.0002	0.0088	0.2354 (1.6263)[a]
β_{FMM}	0.0001	0.0105	0.1429 (1.0494)
β_{FCAPM}	0.0001	0.0093	0.1971 (1.4621)[a]
β_{SMM}	0.0001	0.0084	0.2318 (1.5953)[a]
β_{SCAPM}	0.0001	0.0086	0.2392 (1.6561)[b]
$\beta_{APT(10)}$	0.0004	0.0078	0.3328 (2.3685)[d]
$\beta_{LAPT(10)}$	0.0079	0.0580	0.3910 (2.8250)[c]

Note - 1. t-statistics appear in parentheses.

2. "a", "b", "c", and "d" represent statistical significance at the 0.10, 0.05, 0.025, and 0.005 percent levels, respectively.

3. MR = Naive Market Return.

FMM = Market Model in where parameters were estimated by using the Discounted Weighted Filtering Estimation Method (DWFEM).

FCAPM = CAPM in where parameters were estimated by using the Discounted Weighted Smoothing Estimation Method (DWFEM).

SMM = Market Model in where parameters were estimated by using the DWSEM.

SCAPM = CAPM in where parameters were estimated by using the DWSEM.

APT(10) = the Arbitrage Asset Pricing Theory in which factor loadings (constant over time) were obtained from the factor analysis using all stocks that were continuously listed during the ten-year period, January 1979 ~ December 1988.

LAPT(10) = the Leveraged Asset Pricing Theory in which factor loadings (constant over time) were obtained from the factor analysis using all stocks that were continuously listed during the ten-year period, January 1979 ~ December 1988.

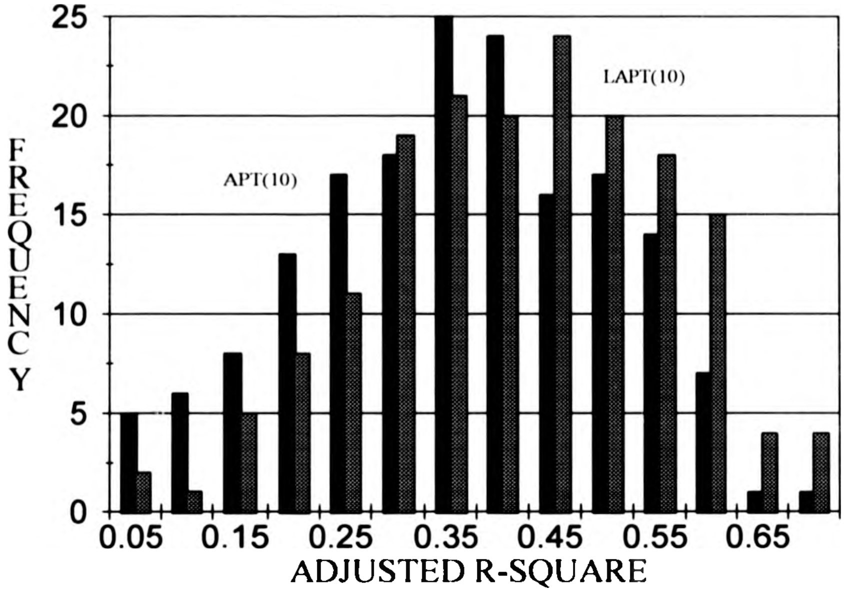
With respect to the two parameter adjustments, the combined filtering and smoothing estimation method outperforms the filtering one with increased predictive power for the market model and the CAPM For example, the SMM predictions and the SCAPM predictions possess better forecast accuracy (0 0084 and 0 0086, respectively, but are not significantly different from zero), and higher adjusted r_a^2 (0 2318 and 0 2392) than the FMM and the FCAPM predictions (0 0105 and 0 0093 for their MSE, and 0 1429 and 0 1971 for their r_a^2) Notably, the market return predictions based on $\beta = 1$ performs almost as well as the SMM predictions and the SCAPM predictions

For the APT(10) model and the LAPT(10) model, Figure 5 3 presents the cross-sectional frequency distribution of adjusted r_a^2 for the 172 individual U K stocks over the ten-year period, Jan 1979 ~ Dec 1988 As Figure 5 3 reveals, the entire distribution of r_a^2 for the LAPT(10) dominates the distribution of the APT(10) at a somewhat higher level The mean r_a^2's were, respectively, 0 3910 for the LAPT(10) and 0 3328 for the APT(10) In the 172 stocks, 143 of them (83 14 percent) had higher r_a^2's with the LAPT(10) The cross-sectional frequency distribution of the difference between the LAPT(10) r_a^2 and the APT(10) r_a^2 for the stocks is presented in Figure 5 4 After regressing the LAPT(10) r_a^2 against the APT(10) r_a^2, we obtain an linear regression model

$$\text{LAPT(10) } r_a^2 = 0\ 1105 + 0\ 8430 \text{ APT(10) } r_a^2,$$

in which the regression coefficients are significantly different from zero, and the correlation coefficient (R^2) of this regression is 73 2% Further Table 5 4 is the one-

Figure 5 3 Adjusted r_a^2 For APT(10) and LAPT(10) over Jan 1979 ~ Dec 1988

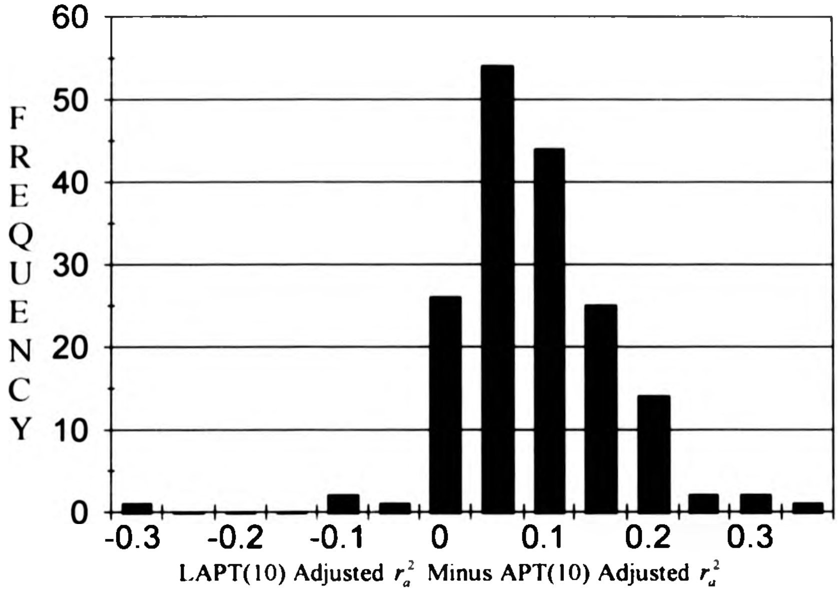


way analysis of variance (ANOVA) for testing the difference between the mean of the APT(10) r_a^2 and the mean of the LAPT(10) r_a^2 Using the critical region equalling 0 05, the critical value of F is $F_{0.05,1,170}$=3 84 Since F-value 15 01 > 3 84, we reject the null hypothesis and conclude that the mean of the LAPT(10) r_a^2 = 39 10 is significantly larger than the mean of the APT(10) r_a^2 = 33 28 (The names of the 172

Table 5 4 The Analysis of Variance on r_a^2

Source	DF	SS	MS	F	P
Regression	1	0 2920	0 2920	15 01	0 000
Error	342	6 6510	0 0194		
Total	343	6 9430			

Figure 5.4 The Differences Between the LAPT(10) Adjusted R-Square and the APT(10) Adjusted R-Square over Jan. 1979 ~ Dec. 1988



firms, their size, and their adjusted r_a^2 for the LAPT and the APT over the ten-year period, Jan. 1979 ~ Dec. 1988, are presented in Appendix B)

From the results of r_a^2 obtained so far, one might have concluded that the LAPT is a better model for predicting the stock returns behaviour. However, let us investigate the robustness of the LAPT predictive ability for different lengths of time period used for study. Table 5.5 presents the ME, the MSE, the r_a^2, and the number of factors, extracted from the factor analysis, of both the LAPT and the APT over each of the nine different lengths of time, starting on January 1979. The results in Table 5.5 indicate that when the length of time is less than 10 years, the APT r_a^2's are slightly

Table 5 5 The Comparisons of the Predictive Ability between the LAPTs and the APTs over Nine Different Lengths of Time Period (the Tests Debt was Updated at the Accounting Year-ends)

Beta Estimates	Time Periods	All Firms ME	All Firms MSE	All Firms adjusted r_a^2	No of Factors
APT(4)	Jan 1979 ~ Dec 1982	0 0013	0 0083	0 3433 (2 1100)[c]	2
LAPT(4)	Jan 1979 ~ Dec 1982	0 2543	0 3913	0 3427 (2 1714)[c]	2
APT(5)	Jan 1979 ~ Dec 1983	0 0010	0 0088	0 2724 (1 8250)[b]	1
LAPT(5)	Jan 1979 ~ Dec 1983	0 0354	0 0885	0 2627 (1 8220)[b]	1
APT(6)	Jan 1979 ~ Dec 1984	0 0008	0 0086	0 2733 (1 8988)[b]	1
LAPT(6)	Jan 1979 ~ Dec 1984	0 0318	0 0839	0 2634 (1 8927)[b]	1
APT(7)	Jan 1979 ~ Dec 1985	0 0007	0 0080	0 2896 (1 9588)[b]	2
LAPT(7)	Jan 1979 ~ Dec 1985	0 0252	0 0703	0 2516 (1 8697)[b]	1
APT(8)	Jan 1979 ~ Dec 1986	0 0006	0 0082	0 2564 (1 9142)[b]	1
LAPT(8)	Jan 1979 ~ Dec 1986	0 0098	0 0273	0.2441 (1 8732)[b]	1
APT(9)	Jan 1979 ~ Dec 1987	0 0004	0 0081	0 3345 (2 3913)[c]	1
LAPT(9)	Jan 1979 ~ Dec 1987	0 0163	0 0515	0 3341 (2 5143)[c]	12
APT(10)	Jan 1979 ~ Dec 1988	0 0004	0 0078	0 3328 (2 3685)[c]	1
LAPT(10)	Jan 1979 ~ Dec 1988	0 0079	0 0580	0 3910 (2 8250)[d]	6
APT(11)	Jan 1979 ~ Dec 1989	0 0004	0 0076	0 3293 (2 3945)[c]	1
LAPT(11)	Jan 1979 ~ Dec 1989	0 0036	0 0536	0 3870 (2 7908)[d]	6
APT(12)	Jan 1979 ~ Dec 1990	0 0004	0 0075	0 3364 (2 4567)[c]	1
LAPT(12)	Jan 1979 ~ Dec 1990	0 0044	0 0457	0 3776 (2 8015)[d]	4

Note - 1 t-statistics appear in parentheses

2 "a", "b", "c", and "d" represent statistical significance at the 0 10, 0 05, 0 025, and 0 005 percent levels, respectively

higher than the LAPT r_a^2's. For the length of time greater than ten years, the LAPT r_a^2's are much higher than the APT r_a^2's. It should be noted that after the year 1987 was added to the test, the predictive ability of both the APT and the LAPT become higher and more common factors[1] were extracted for the LAPT. In order to gain more insights into the effect of the inclusion of the year 1987, let us fix the length of study time period at 4 years and repeat same procedures of investigating the predictive ability of the APT and the LAPT 9 times, starting on Jan. 1979, Jan. 1980, ..., Jan. 1987, respectively. Table 5.6 shows that after the year 1987 is first included in the studying period (Jan. 1984 ~ Dec. 1987), the adjusted r_a^2's jump dramatically from 25.29% up to 43.10% for the APT and from 27.09% up to 42.12% for the LAPT. Further, for the period of Jan. 1985 to Dec. 1988, the adjusted r_a^2 of the LAPT goes up to 55.76%, and outperforms that of the APT (Figure 5.5 reveals the behaviour of adjusted r_a^2's for the APT and the LAPT over four-year period of time between 1979 to 1990). Thus after the year 1987 was included to the test, the predictive ability of both the APT and the LAPT became higher and more common factors were extracted for the LAPT than for the APT. In 1992, McQueen argued that during the depression, stock prices had larger error variances, and the evidence displayed in Figure 5.6 reveals similar conditions in this respect. The variances of stock prices monotonically increase from 41.01 over the first studying period, Jan. 1979 ~ Dec. 1982, to the highest point

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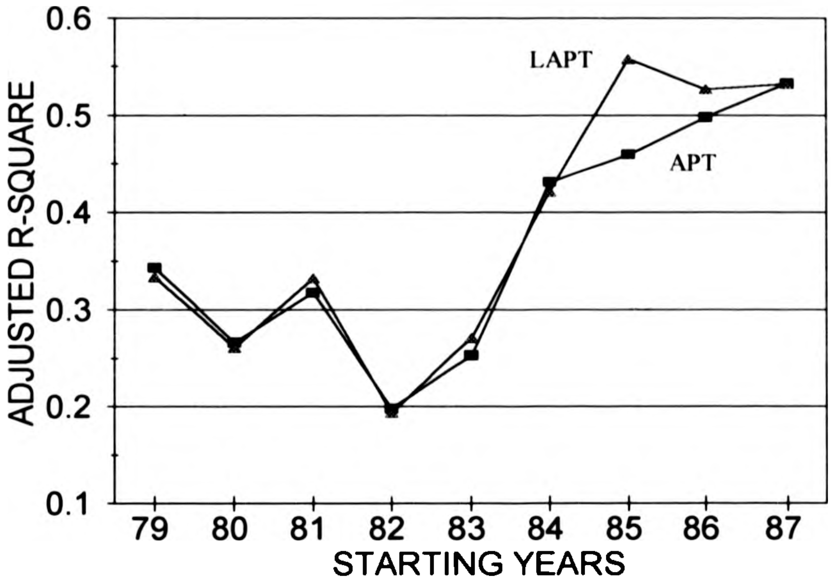
[1] Factor analysis is based on a proper statistical model and is concerned with explaining the covariance structure of the variables. There are several procedures used to estimate the number of factors. These procedures are based upon the characteristics of the data itself rather than upon knowledge of the area or a set of hypotheses (objective). In this empirical work, a mathematical approach, called Guttman's (1954) Lower Bounds for the Rank method, was used to estimate the number of common factors. In this method, Guttman proved that factors with their characteristic roots less than one are trivially important. For a more detailed discussion of how many factors can be extracted from a correlation matrix, see R. L. Gorsuch, Factor Analysis, chapter 8, London: W. B. Saunders Company, 1974.

Table 5.6 The Comparisons of the Predictive Ability between the LAPTs and the APTs over four-year period of time between 1979 to 1990

Beta Estimates	Time Periods	All Firms ME	All Firms MSE	All Firms adjusted r_i^2	No. of Factors	Var(P)
APT	Jan. 1979 ~ Dec. 1982	0.0013	0.0083	0.3433 (2.1100)[c]	2	41.01
LAPT	Jan. 1979 ~ Dec. 1982	0.1962	0.3145	0.3340 (2.1056)[c]	2	
APT	Jan. 1980 ~ Dec. 1983	0.0011	0.0094	0.2660 (1.7519)[b]	1	48.23
LAPT	Jan. 1980 ~ Dec. 1983	0.0282	0.0850	0.2607 (1.7438)[b]	1	
APT	Jan. 1981~ Dec. 1984	0.0008	0.0085	0.3176 (1.9584)[b]	2	54.30
LAPT	Jan. 1981 ~ Dec. 1984	0.0100	0.0780	0.3324 (2.2649)[c]	3	
APT	Jan. 1982 ~ Dec. 1985	0.0010	0.0089	0.1983 (1.6194)[b]	1	64.23
LAPT	Jan. 1982 ~ Dec. 1985	0.0102	0.0440	0.1939 (1.5764)[a]	1	
APT	Jan. 1983 ~ Dec. 1986	0.0008	0.0080	0.2529 (1.6247)[a]	2	75.05
LAPT	Jan. 1983~ Dec. 1986	0.0244	0.0488	0.2709 (1.5576)[a]	3	
APT	Jan. 1984 ~ Dec. 1987	0.0004	0.0079	0.4310 (2.6983)[d]	1	101.33
LAPT	Jan. 1984~ Dec. 1987	0.0043	0.0282	0.4212 (2.6132)[d]	1	
APT	Jan. 1985 ~ Dec. 1988	0.0004	0.0067	0.4595 (2.7548)[d]	2	100.12
LAPT	Jan. 1985~ Dec. 1988	0.0030	0.0205	0.5576 (3.3031)[d]	9	
APT	Jan. 1986 ~ Dec. 1989	0.0003	0.0060	0.4975 (2.9523)[d]	2	99.52
LAPT	Jan. 1986~ Dec. 1989	0.0003	0.0056	0.5267 (3.2807)[d]	4	
APT	Jan. 1987~ Dec. 1990	0.0003	0.0058	0.5327 (3.0786)[d]	2	90.62
LAPT	Jan. 1987 ~ Dec. 1990	0.0004	0.0058	0.5320 (3.1255)[d]	4	

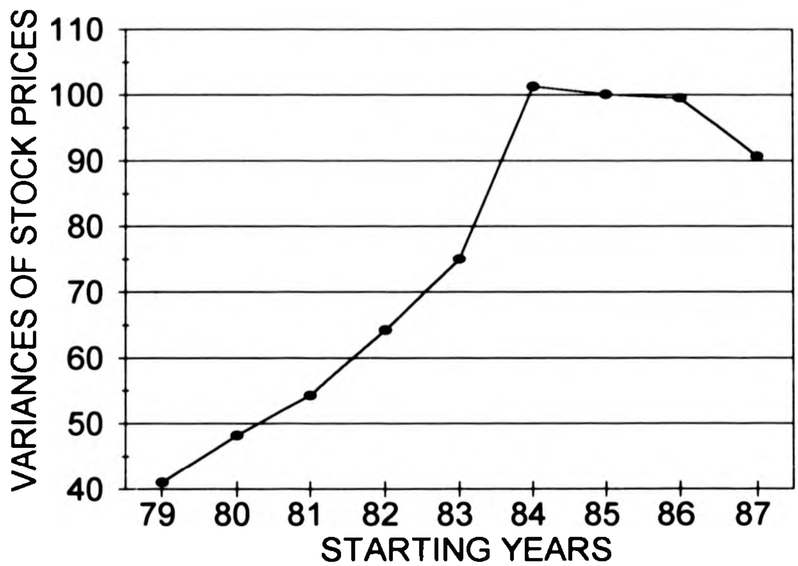
Note - 1. t-statistics appear in parentheses.
2. "a", "b", "c", and "d" represent statistical significance at the 0.10, 0.05, 0.025, and 0.005 percent levels, respectively.
3. Var(P) represents the variance of stock prices.

Figure 5.5 The Behaviour of Adjusted r_a^2 's for the APT and the LAPT over Nine Overlapping Four-Year Periods between 1979 to 1990



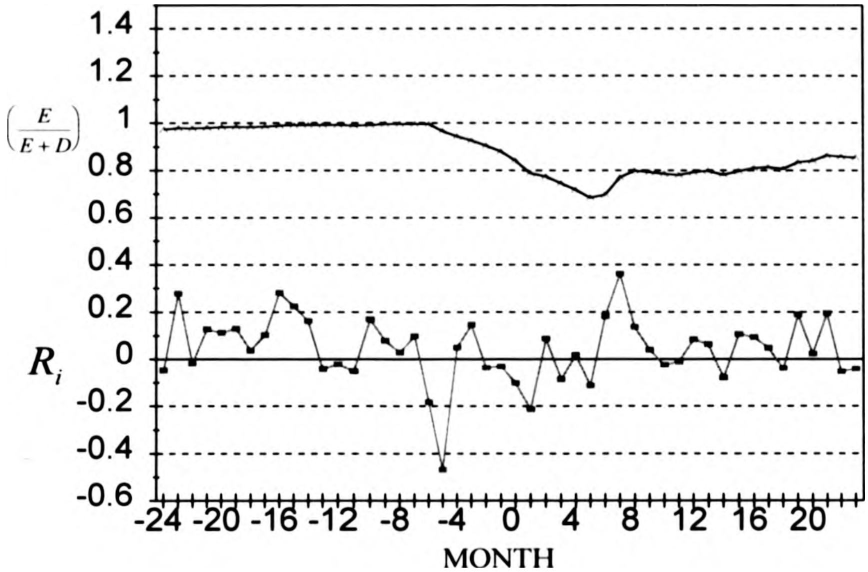
101.33 during the period, Jan. 1984 ~ Dec. 1987, and then slightly decline afterwards to 90.62. The results seem to indicate that the rapid and significant changes associated with the crash in October 1987 could be explained by some economic factors rather than just psychological influences on stock-market pricing. Moreover, the LAPT which makes explicit the leverage factor in its structure performed better than the APT in market valuations around this period.

Figure 5 6 The Behaviour of the Nine Variances of U K Stock Prices Over Nine Overlapping Four-Year Periods between 1979 to 1990



The followings is the evidence of the changing leverage factor Figure 5 7, 5 8, and 5 9 display the behaviour of the inverse leverage ratios ($\frac{E}{E+D}$) and stock returns from October 1985 to September 1989 for the three firms, Cook (William), Vaux Group plc, and Savoy Hotel plc 'A', with the lowest, the median, and the largest average returns, respectively, for the April 1987 to March 1988 period

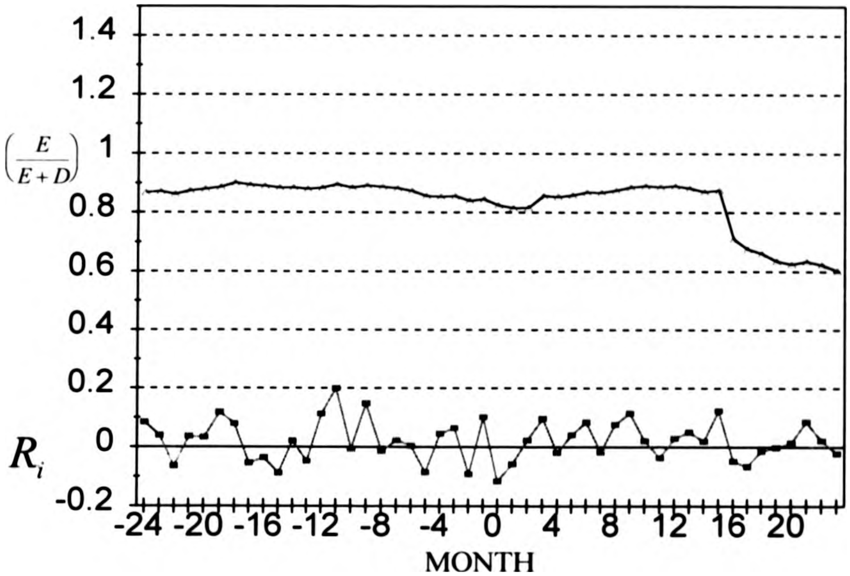
Figure 5.7.. The Behaviour of the Inverse Leverage Ratio $\left(\frac{E}{E+D}\right)$ and Stock Returns Over October 1985 to September 1989 for the Firm, Cook (William), the Company in the Sample with the Lowest Average Return Over the April 1987 to March 1988.



Note:- month 0 represents the crash month Oct. 1987.

The ratio for Cook (William) began with a value near one when the initial borrowings (D) were small. Subsequently, returns were relatively low, and the company increased its debt resulting in the observed decline in the ratio around the time of the crash in 1987.

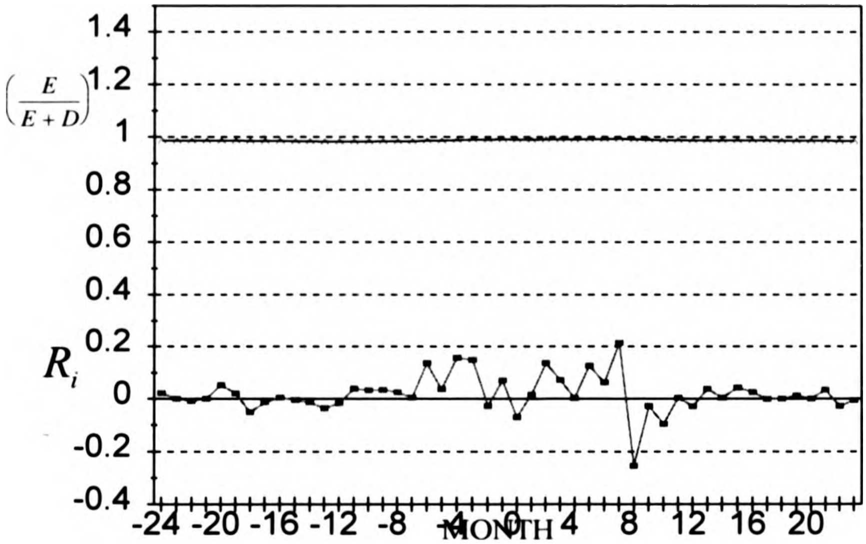
Figure 5.8.. The Behaviour of the Inverse Leverage Ratio $\left(\frac{E}{E+D}\right)$ and Stock Returns Over October 1985 to September 1989 for the Firm, Vaux Group plc, the Company with Median Average Return for the Sample Over the April 1987 to March 1988.



Note:- month 0 represents the crash month Oct. 1987.

Vaux Group began the period with large borrowings (D) relative to equity capitalisation (E) and thus with a low value for the ratio. Low returns towards the end of the period combined with increased borrowing to reduce the ratio.

Figure 5.9. The Behaviour of the Inverse Leverage Ratio $\left(\frac{E}{E+D}\right)$ and Stock Returns Over October 1985 to September 1989 for the Firm, Savoy Hotel plc 'A', the Company in the Sample with the Highest Average Return Over the April 1987 to March 1988



Note:- month 0 represents the crash month Oct. 1987.

The fact that the ratio for Savoy Hotel plc remains close to one is indicative of its very large market capitalisation (E) compared with its debt (D) as can be seen in Appendix B.

Figure 5.10. The Behaviour of Inverse Leverage Ratio Quintile.

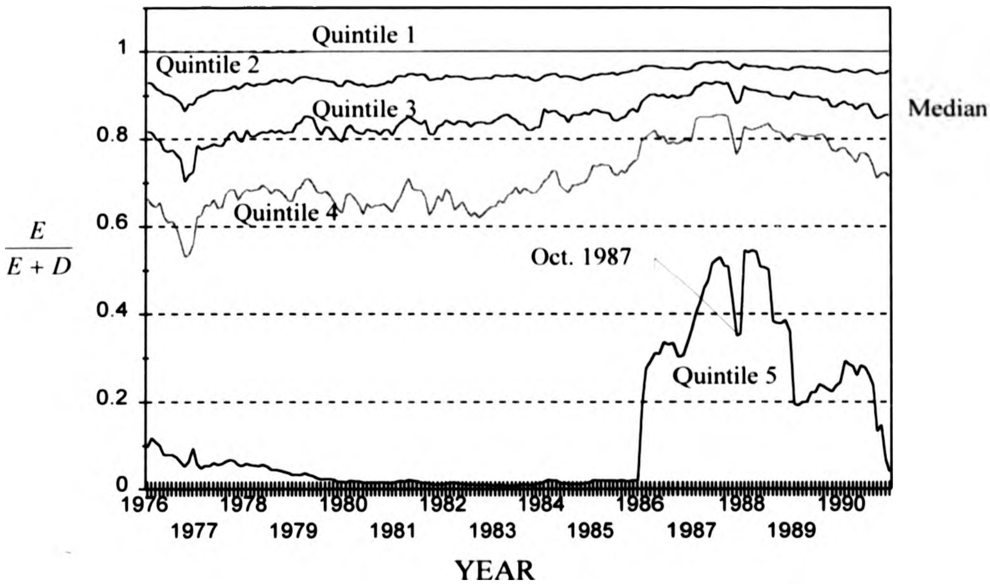


Figure 5.10. displays the behaviour of the inverse leverage ratio $\left(\frac{E}{E+D}\right)$ for the individual quintile firms at each time point. Apparently the smaller the inverse leverage ratio the more it varies. Notice that the inverse leverage ratios move up gradually before October 1987 for the Quintiles 2, 3, and 4, but jumps up abruptly at the beginning of 1986 for the Quintile 5 company. Such changes may result either from changes in market capitalisation or from changes in the debt of these particular companies.

Examples such as these illustrate why it may be important to incorporate the time-varying leverage effect in the systematic risk factors determining the returns on common stock. Although the LAPT predictions have higher r_{it}^2 than the other models (naive market return, FMM, FCAPM, SMM, SCAPM, and APTs) when the length of time is over 9 years, they all possess significant ME and MSE That is to say, even though r_a^2 is large, MSE may still be too large for inferences to be useful in a case where high precision is required

5.4. Summary and Conclusions

This empirical study provides a general and comprehensive view of the characteristics of the various beta estimates using the market model and the CAPM, and the predictive ability of five models In summary, the results of this study indicate that models with more stable beta estimates through time exhibit better ability to predict security returns For example, the filtering and smoothing beta estimates outperform the simply filtering ones due to smaller standard deviation over time In general, the APT's betas display higher forecasting accuracy; they perform better as well in predicting security returns Additionally, using the market returns ($\beta = 1$) straightaway predicts as accurately as those derived from β_{SMM} and β_{SCAPM} But it should be pointed out that the adjusted r_a^2's obtained from the market model and the CAPM are the out-of-sample adjusted r_a^2's, but the adjusted r_a^2's for the APT and the LAPT are within-sample adjusted r_a^2's, as estimates of the factor loadings were produced by factor analysis If the parameters are not stable between the estimation period and the prediction period, the out-of-sample adjusted r_a^2's will be small even if the within-sample adjusted r_a^2's are large

At first sight the results seem to support the Leveraged Asset Pricing Theory with its high r_a^2 in certain periods. After comparing the robustness of the predictive ability of the LAPT to that of the APT for different lengths of time periods, the results seem to indicate that the Leveraged Asset Pricing Theory is better in predicting stock return behaviour in the long run (over 9 years). Moreover, when the year 1987, in which stock prices have larger error variances, was added to the test, the predictive ability of both the APT and the LAPT become higher and more common factors were extracted for the LAPT. We know that when stock price goes down implying a decline in market capitalisation (E), all other things being equal, the leverage factor goes up ($\frac{E}{E+D}$ goes down). In the practice, $R_{iL,t} - R_{ft}$ was used as the input data for extracting the factor loadings for the APT; whereas $\left(R_{iL,t} - R_{ft}\right)\left(\frac{E_{i,t-1}}{E_{i,t-1} + D_{i,t-1}}\right)$ was used as the input data for extracting the factor loadings for the LAPT. That is to say, in a market depression, the stock market values tend to be lower, so the input returns ($R_{iL,t}$) will be given less weights for the case of the LAPT as they are more volatile, unlike the case of the APT. However, the LAPT leverage-adjusted beta estimates have higher bias. Although they may have captured the true linear relationship between systematic risk and actual returns, this relationship is obscured in the accuracy measure (MSE) by high bias (ME) in the estimates.

Furthermore, there are three important sources of error in measuring the leverage variable in these particular tests: (a) As discussed in section 4.3., the book value of debt will not be a suitable proxy for the market value of debt during the periods when interest rates are extremely volatile (b) It should be noted that long-term liability reported by Datastream includes loans from group companies and associates, so loans of a company from its group companies and associates will be cancelled out and may not affect the company's risk (c) In the tests, debt was measured as the book value of long-term reported liabilities obtained from the Datastream company balance sheet data and was updated at the accounting year-ends Thus, the monthly debt levels were not reported This may also produce estimation bias

Table 5 7 presents the results obtained by employing similar empirical procedures to those used for Table 5 5 , but in these tests Debt is adjusted each year as before but interpolated monthly Generally speaking, the LAPT adjusted r_a^2's do not change much, compared with those in Table 5 5 , except when the length of time period is less than 9 years When the test period is 9 years the LAPT adjusted r_a^2's is about 9% higher than that obtained in Table 5 5

This preliminary result illustrates that there may be scope for further improvement in the empirical performance of the LAPT relative to other models by reducing the errors in the leverage variable

Table 5.7. The Comparisons of the Predictive Ability between the LAPTs and the APTs over Nine Different Lengths of Time Period (the Tests Debt was Adjusted Each Year and Interpolated Monthly)

Beta Estimates	Time Periods	All Firms ME	All Firms MSE	All Firms adjusted r_a^2	No. of Factors
APT(4)	Jan. 1979 ~ Dec. 1982	0.0013	0.0083	0.3433 (2.1100)[c]	2
LAPT(4)	Jan. 1979 ~ Dec. 1982	0.1962	0.3145	0.3340 (2.1056)[c]	2
APT(5)	Jan. 1979 ~ Dec. 1983	0.0010	0.0088	0.2724 (1.8250)[b]	1
LAPT(5)	Jan. 1979 ~ Dec. 1983	0.0351	0.0898	0.2674 (1.8558)[b]	1
APT(6)	Jan. 1979 ~ Dec. 1984	0.0008	0.0086	0.2733 (1.8988)[b]	1
LAPT(6)	Jan. 1979 ~ Dec. 1984	0.0317	0.0858	0.2678 (1.9309)[b]	1
APT(7)	Jan. 1979 ~ Dec. 1985	0.0007	0.0080	0.2896 (1.9588)[b]	2
LAPT(7)	Jan. 1979 ~ Dec. 1985	0.0249	0.0716	0.2554 (1.8997)[b]	1
APT(8)	Jan. 1979 ~ Dec. 1986	0.0006	0.0082	0.2564 (1.9142)[b]	1
LAPT(8)	Jan. 1979 ~ Dec. 1986	0.0094	0.0273	0.2483 (1.9103)[b]	1
APT(9)	Jan. 1979 ~ Dec. 1987	0.0004	0.0081	0.3345 (2.3913)[c]	1
LAPT(9)	Jan. 1979 ~ Dec. 1987	0.0066	0.0574	0.4226 (3.0764)[c]	7
APT(10)	Jan. 1979 ~ Dec. 1988	0.0004	0.0078	0.3328 (2.3685)[c]	1
LAPT(10)	Jan. 1979 ~ Dec. 1988	0.0068	0.0388	0.3165 (2.3384)[d]	1
APT(11)	Jan. 1979 ~ Dec. 1989	0.0004	0.0076	0.3293 (2.3945)[c]	1
LAPT(11)	Jan. 1979 ~ Dec. 1989	0.0072	0.0394	0.3173 (2.3734)[d]	1
APT(12)	Jan. 1979 ~ Dec. 1990	0.0004	0.0075	0.3364 (2.4567)[c]	1
LAPT(12)	Jan. 1979 ~ Dec. 1990	0.0044	0.0455	0.3806 (2.8377)[d]	4

Note - 1. t-statistics appear in parentheses.

2. "a", "b", "c", and "d" represent statistical significance at the 0.10, 0.05, 0.025, and 0.005 percent levels, respectively.

CHAPTER 6

THE EMPIRICAL METHODOLOGY FOR U.K. THE STOCK MARKET OVERREACTION STUDY: WITH PRELIMINARY DATA ANALYSIS

6.1. Introduction

Whether an investment is successful or not depends on one's ability to estimate its future expected value Other than the "firm-foundation theory[1]" and the "modern investment theory[2]", some investors use the "castle-in-the-air theory", first enunciated by the famous economist, John M Keynes (1936) to assess the valuation of stocks In his co-authored book, *Predictability of Stock Market Prices*, Morgenstern (1970) quoted a Latin maxim which can adequately explain the "castle-in-the-air" theory

"Res tantum valet quantum vendi potest."

That means "a thing is worth only what someone else will pay for it." Unlike the other valuation theories, the "castle-in-the-air" theory is focused on the psychological investigation of investors rather than on the financial evaluation of the firms

Admittedly, the human being is a gregarious animal The "castle-in-the-air" theory would suggest analysing crowd psychology and the resulting behaviour of investors to anticipate the future value of the investments The study of crowd

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[1] In the investment community, the firm-foundation theory is one of the approaches used in the valuation of investments The theory itself stresses the intrinsic value of each investment instrument

[2] Modern investment theory, born in academia during the 1970s, is a new approach which was first developed to solve the more complex asset choice problems, by introducing risk into evaluation process

behaviour dates back to 1895 when Le Bon first proposed a theme of contagion, a circular chain reaction of emotional facilitation, which was subsequently supported by Allport (1924) positing that individuals respond to and stimulate others, generating an ascending spiral of crowd emotionality In the history of markets, we find a number of such phenomena, e g the tulip bulb craze of the 1630s, apparently caused by greed reinforced by crowd psychology That is to say, the cognitive misperceptions of investors draw the prices of investments away from intrinsic value The resulting castle-in-the-air prices may persist for a period of time, but eventually should be corrected In the stock Market, recent research has found evidence which appears to support that equity returns exhibit this tendency to mean reversion[1]

The rest of this chapter is organised as follows Section 6 2 starts with a brief review of the existing evidence on mean reversion Section 6 3 discusses long-term overreaction behaviour in the stock market Section 6 4 documents three international empirical studies which replicated De Bondt and Thaler's overreaction tests for the Belgian, Japan, and Canadian stock markets Section 6 5 states the objectives of this empirical study and contains preliminary results using the same data as for the previous studies in Chapters 4 and 5 Section 6 6 describes data sources and the methodology for testing U K stock market overreaction The portfolio construction procedures and two statistical tests used in this empirical research are described in section 6 7 Finally, section 6 8 ends this chapter with a summary

[1] For the literature of mean reversion review, refer to Kupiec (1993), De Bondt (1989), and De Bondt and Thaler (1989)

6.2. Literature Review of Mean Reversion of Stock Prices

Summers, in his 1986 paper, argued that the fact that most evidence is in favour of the hypothesis of market efficiency does not mean that stocks are rationally priced. The reason is that the standard methods which have been used to test the efficient market hypothesis have little power to detect "anomalies". He then proposed a transitory component caused by speculative forces and demonstrated that mean reversion would be difficult to detect. Thus, there is little reason to expect that market investors would be able to identify and arbitrage away all of the transition component. Therefore, ruling out long-term mean reversion with arbitrage arguments may not be sufficient. Using autocorrelations of multiperiod returns, Fama and French (1988) considered the transitory component first proposed by Summers (1986) and examined long-horizon return regressions for the CRSP value- and equally- weighted indices, for portfolios of stocks formed by both size and industry classification, and for individual stocks over observation intervals of one to 10 years from 1925 to 1985. The results of the regression slope coefficients of firm-sized portfolio returns revealed a U-shaped pattern across increasing return horizon and were consistent with the Summers model of mean-reversion. In a subsequent paper, Poterba and Summers (1988) employed three testing methods (Fama and French's (1988) regression tests, the variance-ratio test which has the highest power against the alternative hypothesis of a persistent autoregressive component of stock prices, and likelihood-ratio tests) to test long-horizon mean reversion in stock returns for U.S. from 1871 to 1985 and for seventeen other countries which include the U.K.. They also found that stock prices exhibited statistically significant long-term mean-reversion and concluded that a substantial part of the variance in monthly returns could be explained by a transitory component. Further, Jegadeesh (1990), using an improved regression model in which 1-month returns represented the dependent variable and lagged multiyear returns represented the independent variables to test the transitory component, investigated the seasonal pattern in the phenomenon of stock price mean-reversion. He found that the mean-reversion phenomenon was entirely concentrated in the month of January on the New York Stock Exchange (NYSE) for the period 1926-1988 and on the London Stock Exchange as well for the period 1955-1988.

However, Kim, Nelson, and Startz (1991) re-tested the mean-reversion on sub-samples of the data used by Poterba and Summers, and by Fama and French; and they found that the significant statistical evidence of mean reversion was generated only during the second World War. Furthermore, they employed the stratified randomisation simulation method, which generates a sampling distribution that depends on neither the assumptions constrained on any stock return distributions nor on asymptotic approximations for test statistics. The rejection of the results showed that, in the conventional mean-reversion studies, the null hypothesis of temporal independence of stock prices is due to overstating the normal distribution and underestimating the standard error estimates. Cecchetti, Lam, and Mark (1990) took a different approach to explain the mean-reversion phenomenon. They constructed an equilibrium asset pricing model which was derived from the Lucas's (1978) equilibrium asset pricing model based on the constant relative risk aversion utility function in which the stochastic process based on Hamilton's (1989) Markov switching process was assumed to govern the exogenous time path of economic fundamentals --

consumption, dividends, and GNP. Then, they constructed the Monte Carlo distributions of Poterba and Summers' variance ratio statistics and Fama and French's long-horizon return regression coefficients which were generated by their equilibrium model. The results suggested that if investors' behaviour exhibits consumption smoothing, stock prices are mean reverting, provided that their equilibrium model is true. Moreover, Richardson and Stock (1989) argued that the usual asymptotic distribution of the variance ratio statistics and of the long-horizon regression coefficients are not appropriate in long-period return tests. They developed an alternative asymptotic distribution in which the ratio of the length of return time period to sample size was assumed to be a fixed constant (rather than zero) while sample size becomes large. On this basis, the evidence against the random walk hypothesis loses much of its significance.

6.3. Stock Market Overreaction

One of the explanations that have been discussed in the literature for mean-reversion is systematic investor "overreaction". As early as 1949, Benjamin Graham held the view that stocks whose prices seem to be low relative to their fundamental value move back to their intrinsic value within a few years. Similar contrarian strategies in terms of examining the mean reversion hypothesis, i.e. low P/E ratios, high dividend yields, low price to book value ratios[4], etc., have been published. If contrarian investment strategies are successful, an implication would be that the market overreacts to news events, and subsequently corrects itself.

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[4] Price to book value ratios contrarian strategy refers to Keim (1985), Rosenberg, Reid, and Lanstein (1985). References for other contrarian strategies refer to those mentioned in section "anomalies".

The most influential study of long-term market overreaction is the controversial work of De Bondt and Thaler (1985), who proposed that buying portfolios of prior "losers" and selling portfolios of prior "winners" short earns abnormal returns, especially in January Using monthly return data for NYSE stocks between January 1926 and December 1982, they calculated cumulative excess returns for individual stock returns over non-overlapping formation periods of two to five years, constructed portfolios of the most extreme winners and losers (e g the extreme decile portfolios or portfolios of 35 or 50 stocks) over the formation periods, and then tested the performances of winners' and losers' excess returns for the test periods of two to five years following the portfolio formation dates They found that both winner and loser portfolios exhibited mean-reversion, but not symmetrically; the excess return reversals for losers were more pronounced than those for winners, especially in January In addition, the more extreme the movement of the initial prices, the greater the subsequent reversion These astonishing results attracted much attention For example, Jones (1987), Brown and Harlow (1988), Chan (1988), Ball and Kothari (1989), Pettengill and Jordan (1990), Alonso and Rubio (1990), Zarowin (1990), and Chopra, Lakonichok, and Ritter (1992) replicated De Bondt and Thaler's (1985) experiment of long-term overreaction and checked the robustness of their findings Table 6 1 gives the results of these studies

In addition to the evidence of stock market overreaction in long-term price movements, several studies investigated short-term price movements taking an approach similar to that of De Bondt and Thaler (1985) For instances, Dyl and Maxfield (1987), Bremer and Sweeney (1988), and Brown, Harlow, and Tinic (1988)

Table 6.1 Long-Term Stock Market Overreaction: An Overview of the Literature

Authors	Sample	Portfolio formation period	Methods	Summary of the findings
De Bondt & Thaler (1985)	monthly returns 1926~1982 NYSE companies	36 months	study the top/bottom 35 stocks of cumulative residual returns	three years after formation date winners:-5.0% losers:+19.6%
Chan (1988)	monthly returns 1926~1985 NYSE companies	36 months	study the top/bottom 35 stocks (decile) of cumulative residual returns	three years after formation date winners:-4.6% (-4.7%) losers:+29.4% (+25.1%)
Ball & Kothari (1989)	yearly returns 1926~1986 NYSE companies	60 months	study the top/bottom 50 stocks of cumulative residual return	five years after formation date winners:-10.2% losers:+5.45%
Zarowin (1990)	monthly returns 1927~1980 NYSE companies	36 months	study the top/bottom quintiles of cumulative residual returns	three years after formation date losers minus winners:+17.4%
Pettengill & Jordan (1990)	daily returns 1962~1986 NYSE and AMEX companies	36 months	study ventiles of cumulative residual returns	three years after formation date winners:+7.00% (ventile 20) losers:+21.46% (ventile 1)
Alonso & Rubio	monthly returns 1965~1984 Spanish companies	36 months	study the top/bottom 5 companies of cumulative residual returns	three years after formation date losers minus winners:+36.9%
Chopra, Lakonishok, & Ritter (1992)	yearly returns 1926~1986 NYSE companies	60 months	study ventiles of cumulative residual returns	five years after formation date winners:+66.5% losers:+136.5%
Kryzanowski & Zhang (1992)	monthly returns 1950~1988 TSE companies	12~120 months	study the top/bottom deciles of cumulative residual returns	five years after formation date winners:-58% losers:34%

constructed winner and loser portfolios based on one-day performance of residual returns, Howe (1986) and Lehmann(1990) considered one-week stock performances, and Rosenberg and Rudd (1982), Rosenberg, Reid, Lanstein (1985), Jegadeesh (1990), and Brown and Harlow (1988) ranked stocks based on one-month performance They consistently found that losers outperformed winners in the subsequent periods[5]

Several reasons have been offered to explain this systematic (non-zero) residual behaviour -- overreaction:

(1) Investor Psychological: De Bondt and Thaler's (1985) overreaction hypotheses are actually based on psychological evidence (Kahneman and Tversky (1973), Grether (1980), and Shiller (1981)) that individuals' memories seem not to last long, they tend to overweight recent, especially dramatic or unanticipated, news events in making forecasts and judgements. As noted by Williams (1938) in his *Theory of Investment Value* "prices have been based too much on current earning power, too little on long-run dividend paying power." (p 19, 1938)

(2) Time-varying risk: Chan (1988) and Ball and Kothari (1989) found that the winner-loser overreaction effect is due to intertemporal changes in risks and expected returns, and when beta is allowed to vary over time, the overreaction phenomenon disappears. De Bondt and Thaler (1987), Zarowin (1990), Kryzanowski and Zhang (1992), Chopra, Lakonishok, and Ritter (1992), and Jegadeesh and Titman (1993), however, maintained that the overreaction effect is economically important even after adjusting for changes in beta.

[5] A more detailed literature review of short-term overreaction can be found in De Bondt (1989), and De Bondt and Thaler (1989).

(3) Omitted variables due to misspecification of the equilibrium pricing model. For example, Pettengill and Jordan (1990), Fama and French (1988),(1992), and Zarowin (1989),(1990) proposed that this phenomenon is a manifestation of the well-known size effect which has been reviewed in section 2.4.1

(4) Tax-loss selling: De Bondt and Thaler (1985),(1987), Zarowin (1990), Pettengill and Jordan (1990), and Chopra, Lakonishok, and Ritter (1992) found that almost all of the "winner-loser" effect occurred in January, which may reflect tax-loss selling pressure (see section 2.4.2.), while Pettengill and Jordan (1990) argued that this effect was not explainable by tax-loss selling as extreme winner and loser portfolios both experienced large excess returns in January

(5) Return volatility: The evidence for overreaction was weaker when datum in the depression and the World War II period were excluded. McQueen (1992) argued that during the depression and World War II periods, stock prices have larger error variances and exhibit the strongest mean-reverting tendencies. After abandoning assumptions of normally distributed returns as in Kim, Nelson, and Startz (1991) and using generalised least-squares randomisation tests instead of ordinary least-squares tests to examine long-horizon stock returns from 1926 to 1987, he found that the random walk null hypothesis cannot be rejected.

(6) Positive feedback trading: Jegadeesh and Titman (1993) proposed a relative strength trading strategy that buys past winners and sells past losers based on their price movements over the past 3 to 12 months. Unlike studies based on short-term (1 week or 1 month) and long-term (3 to 5 years) return reversals, the strategy generates significant positive returns over 3- to 12-month horizons. Such positive feedback investment strategies over 3- to 12-month horizons practised by uninformed investors

would move prices further away from their fundamental values temporarily and, therefore, would cause prices to overreact This work is consistent with the analysis of De Long, Shleifer, Summers, and Waldmann (1990)

Finally, (7) Market inefficiency may be one of the reasons

6.4. International Evidence of Stock Market Overreaction

Using methodology similar to De Bondt and Thaler's (1985), Vermaelen and Verstringe (1986) investigated the overreaction effect for the Belgian stock market. They argued that winners and losers' mean reverting reactions reflected changing risks. Dark and Kato (1986) tested the overreaction hypothesis on the Japanese stock market for the period between 1964 and 1980 and found that the cumulative abnormal returns of decile loser portfolios (based on preceding three-year periods) outperformed those of the decile winner portfolios for an average of 69.7 percent. Alonso and Rubio (1990) examined the overreaction hypothesis within the Spanish capital market for the period between 1967 and 1984, they found that five extreme losers earn excess returns of 24.5% more than the five extreme winners one year after portfolio formation date, and the results are still consistent even after correcting for firm size. Kryzanowski and Zhang (1992) used Toronto Stock Exchange monthly return data to test the overreaction hypothesis over the 1950 to 1988 period and found more complex results revealing that winners kept winning and losers kept losing within the next one (and two) year(s) after the portfolio formation date, and reversal behaviour appeared insignificant over longer formation/test periods of up to ten years

6.5. Empirical Research for U.K. Stock Market Overreaction

The objective of this research is to test whether U.K. stock market returns revert (overreaction hypothesis) or the benchmark models are misspecified. The methodology adopted in this research allows for heteroskedasticity. Therefore, based on the definitions of four theoretical models of the efficient market, the test of overreaction in this chapter is associated with a test of the "fair game" model rather than a test for randomness.

Before describing the methodology and data of the U.K. market overreaction study, it would be worthwhile undertaking a brief analysis first by employing the estimation adjustments and the LSPD sample return data in order to obtain a preliminary prospective on the characteristics of the U.K. "winner" and "loser" portfolios. These portfolios are identified respectively as the top and bottom deciles of firms formed at the end of December 1982 over the portfolio formation period 1980-1982 and based on the averaged cumulative abnormal returns (ACAR) rankings. Performance was measured by using three different benchmark expected returns (the naive index , the market model, and the Sharpe-Lintner CAPM) with two estimations over the subsequent three-year portfolio test period 1983-1985.

Time serial points of beta estimates, median market capitalisation, and ACARs over the portfolio formation and test periods for the winners and the losers samples for various performance measures are reported in Table 6.2. At first sight the results of ACARs seem to support the market overreaction hypothesis (see Figure 6.1.) that stocks with the lowest returns (losers) over time period 1980-1982 subsequently outperform the stocks with the highest returns (winners) over time period 1983-1985, but market capitalisation effects obscure this conclusion. Like Fama and French (1986), and Zarowin (1989), (1990) for U.S.A. data, and Kryzanowski and Zhang (1992) for Canadian data, the losers have lower median market capitalisation and higher beta estimates than the winners over the portfolio formation and test periods[6]. It is clear from Table 6.2. that both winner and loser portfolios experience large changes in market capitalisation (the last marked price multiplied by the number of ordinary shares) during both the portfolio formation and the portfolio test periods. For example, the average market value change of loser portfolios is -47.08%, and that of winner portfolio is 180.32% for both FMM and FCAPM benchmarks during the portfolio formation period. During the portfolio test period, the increase of 180.34% in the market value of loser portfolio is larger than that of 34.92% in the market value of winner portfolio. The fact that loser stocks are smaller-sized firms than winners may perhaps explain these outcomes. That is to say, the reversal effect (overreaction) may be related to the well-known size effect anomaly.

[6] There is only one winner and one loser portfolio in these preliminary results, therefore no tests of the difference between winner and loser portfolios were carried out. Notice that there are some extreme observations in the loser portfolio of the FMM benchmark during the portfolio formation period as the beta estimates of the filtering market model have, in general, higher mean square errors (MSE) which have been described in section 5.2.1.

Table 6.2. Beta Estimates, Median Market Capitalisation, and ACAR for The Winner and Loser Portfolios of Five Performance Measures over the Three-year Portfolio Formation/Test Periods (1980-1985)

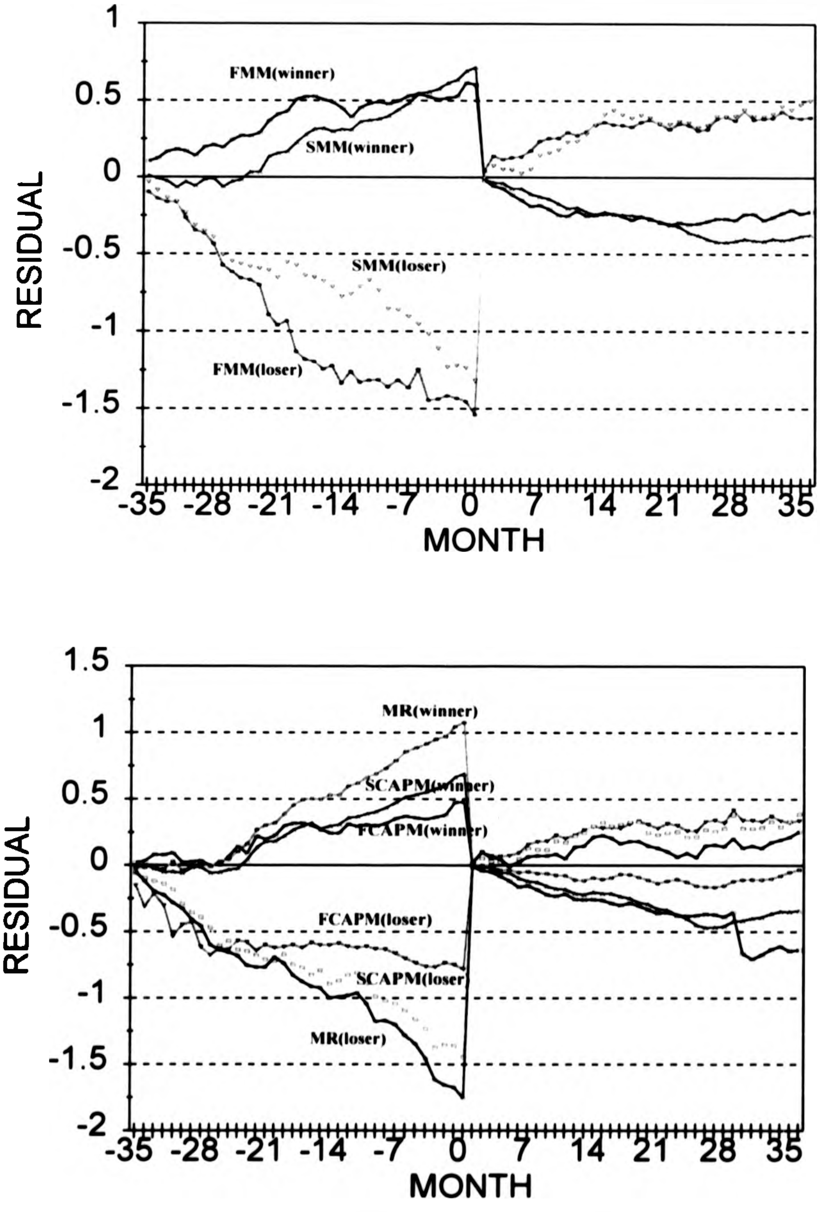
	FMM								SMM							
	Winner				Loser				Winner				Loser			
t	Alpha	Beta	MV	ACAR	Alpha	Beta	MV	ACAR	Alpha	Beta	MV	ACAR	Alpha	Beta	MV	ACAR
-30	-0.0217	0.8186	(410)	0.1380	0.0953	5.0545	(441)	-0.3477	0.0120	0.8730	(430)	-0.0579	-0.0103	0.8865	(905)	-0.3091
-24	-0.0093	0.9784	(524)	0.2680	-0.0488	2.6424	(382)	-0.6669	0.0097	0.8571	(577)	0.0344	-0.0103	0.8865	(809)	-0.5800
-18	0.0258	0.8734	(889)	0.5232	0.0199	0.7846	(722)	-1.1828	0.0120	0.8301	(1,048)	0.2755	-0.0084	0.8851	(788)	-0.6403
-12	0.0139	0.8916	(1,126)	0.4517	-0.0277	1,2979	(488)	-1.3290	0.0118	0.8289	(1,284)	0.3608	-0.0065	0.8840	(596)	-0.7109
-6	0.0303	0.8258	(952)	0.5434	-0.0285	1.2845	(378)	-1.4455	0.0119	0.8057	(1,397)	0.5468	-0.0037	0.8923	(470)	-0.9531
0	0.0418	0.7934	(1,188)	0.6026	-0.0394	1.0206	(351)	-1.5382	0.0106	0.7939	(2,046)	0.7152	-0.0022	0.8850	(415)	-1.3198
A.C .(%)	0.0065	0.8332	180.32%		0.0309	2.1432	-47.08%		0.0115	0.8358	354.07%		-0.0069	0.8801	-67.74%	
6	0.0223	0.6818	(1,876)	-0.1895	-0.0275	1.0863	(342)	0.1738	0.0096	0.8008	(2,893)	-0.1090	0.0015	0.9220	(497)	0.0524
12	0.0121	0.7275	(1,907)	-0.2547	-0.0058	0.9581	(417)	0.2982	0.0082	0.7961	(2,647)	-0.2256	0.0025	0.9543	(633)	0.2812
18	0.0022	0.8756	(1,996)	-0.2552	-0.0016	1.0719	(485)	0.3576	0.0075	0.7931	(2,914)	-0.2562	0.0037	0.9666	(816)	0.4061
24	-0.0000	0.7918	(2,406)	-0.3003	0.0013	0.8477	(617)	0.3038	0.0065	0.7846	(3,176)	-0.3769	0.0038	0.9751	(976)	0.3263
30	0.0080	0.8139	(2,140)	-0.2378	0.0116	0.7791	(437)	0.3763	0.0060	0.7812	(3,063)	-0.4107	0.0048	0.9976	(1,488)	0.4000
36	0.0079	0.8720	(2,454)	-0.2204	0.0130	0.6746	(951)	0.3940	0.0044	0.8103	(3,746)	-0.3748	0.0039	0.9985	(1,987)	0.5015
A.C .(%)	0.0279	0.7685	34.92%		-0.0042	0.9368	180.34%		0.0095	0.7932	55.74%		0.0028	0.9607	399.42%	

Table 6.2. -- Continued.

	FCAPM						SCAPM						MR					
	Winner			Loser			Winner			Loser			Winner			Loser		
t	Beta	MV	ACAR	Beta	MV	ACAR	Beta	MV	ACAR	Beta	MV	ACAR	Beta	MV	ACAR	Beta	MV	ACAR
-30	1.1007	(410)	0.0194	1.8582	(441)	-0.4480	0.9425	(519)	-0.0606	1.0330	(642)	-0.2895	-	(470)	-0.0402	-	(787)	-0.3249
-24	1.0616	(524)	0.1426	1.1478	(382)	-0.5689	0.9498	(706)	-0.0260	1.0382	(418)	-0.6384	-	(599)	0.1059	-	(703)	-0.6822
-18	0.7958	(889)	0.3178	1.2203	(722)	-0.5975	0.9298	(1,149)	0.2666	1.0180	(682)	-0.7470	-	(1,048)	0.4550	-	(722)	-0.8292
-12	0.9347	(1,126)	0.3122	1.1677	(488)	-0.6092	0.9260	(1,458)	0.3614	1.0045	(480)	-0.8254	-	(1,130)	0.5971	-	(480)	-0.9819
-6	0.7729	(952)	0.3694	1.1669	(378)	-0.7007	0.9207	(2,286)	0.5160	0.9871	(378)	-1.0951	-	(1,494)	0.8547	-	(378)	-1.2816
0	0.6728	(1,188)	0.4786	1.2895	(351)	-0.7836	0.9265	(3,341)	0.6894	0.9828	(326)	-1.4475	-	(2,112)	1.0777	-	(326)	-1.7536
A.C. (%)		180.32%			-47.08%			310.52%			-56%			368.77%			-72.35%	
6	0.7521	(1,876)	-0.1623	1.2638	(342)	0.0957	0.9305	(3,319)	-0.0977	0.9602	(335)	0.0504	-	(3,106)	-0.0533	-	(335)	0.0213
12	0.8281	(1,907)	-0.2540	1.1053	(417)	0.2306	0.9344	(3,475)	-0.2112	0.9561	(417)	0.2241	-	(2,667)	-0.1098	-	(417)	0.1386
18	0.9030	(1,996)	-0.2837	1.0566	(485)	0.3155	0.9381	(3,747)	-0.2469	0.9448	(471)	0.3259	-	(3,569)	-0.0699	-	(471)	0.1814
24	0.9482	(2,406)	-0.3828	1.0098	(617)	0.2613	0.9443	(4,457)	-0.4000	0.9439	(617)	0.2123	-	(3,936)	-0.1236	-	(617)	0.0919
30	0.9154	(2,140)	-0.3491	0.8980	(437)	0.3422	0.9502	(4,401)	-0.4155	0.9380	(745)	0.2778	-	(3,997)	-0.1066	-	(344)	0.1314
36	0.9202	(2,454)	-0.3338	0.8950	(951)	0.3396	0.9657	(6,726)	-0.3407	0.9468	(1,282)	0.3886	-	(5,610)	-0.0335	-	(944)	0.2556
A.C. (%)		34.92%			180.34%			81.24%			323.33%			129.65%			208.08%	

Note:- 1.MV represents Median Market Capitalisation which is in thousands of pounds.
2. A.C. represents Average Change.
3. t=0 presents the portfolio formation month (December of 1982).
4. FMM = Market Model in where parameters were estimated by using the Discounted Weighted Filtering Estimation Method (DWFEM).
SMM = Market Model in where parameters were estimated by using the Discounted Weighted Smoothing Estimation Method (DWSFM).
FCAPM = CAPM in where parameters were estimated by using the DWFEM.
SCAPM = CAPM in where parameters were estimated by using the DWSEM.
MR = Naive Market Return.

Figure 6.1. The Performance of Averaged Cumulative Average Residuals (ACAR) for Winner and Loser Portfolios of 20 Stocks Over Three-Year Portfolio Formation/Test Periods (t=0, Dec. 1982), Evaluated Using 5 Alternative Benchmarks.



Note:- Vertical Axis = ACAR, Horizontal Axis = Time in Months Relative to Portfolio Selection (i.e. month 0 is month of portfolio selection).

In 1986, Dimson and Marsh investigated long-term performance of the U K stock returns with respect to the event study of press recommendations, they employed two size-adjusted methods, together with other benchmarks (market adjusted, market model, and CAPM) and presented persuasive evidence that, if the U K stock market is efficient, the measured performance can be significantly affected by the firm size effect especially in the study of long-term price behaviour As proposed by Dimson and Marsh (1986) and subsequently adopted by Lakonishok and Vermaelen (1990), and Agrawal, Jaffe, and Mandelker (1992) with respect to different event studies (e g U K press recommendations, repurchase tender offers, and company mergers), this overreaction study also employed their size-adjusted model which controls both size and beta as benchmark to measure stock abnormal return performance

6.6. Empirical Research Methodology and Data Sources

The methodology of this empirical research is based on De Bondt and Thaler's (1985) paper as originally proposed by Beaver and Landsman (1981) Also, this study incorporates the improvements of recent overreaction research with two extensions -- (i) the nontrading effect and (ii) variations in parameters (for estimating abnormal returns) The nontrading problems are corrected by using the Trade-to-Trade (TT) method and problems of variations in parameters are relieved by using the Discounted Weighted Smoothing Estimation (DWSE) method[7] The following is a brief description of the revised methodology and the data sources

[7] In the light of the results in chapter 5, the smoothing estimation method was employed in this chapter rather than the filtering estimation method

The residual return on a security is the difference between the realised return (R_{it}) and an appropriate benchmark expected return, $E[R_{it}|D_T]$, given the information made available both 5 years before and 5 years after time t, this is called smoothing the return series. The residual return is defined as $\mu_{it} = R_{it} - E[R_{it}|D_T]$, where D_T represents the complete set of information throughout the time period $t-60 \leq T \leq t+60$. The empirical analysis is based on four types of return residuals[8]: (1) market-adjusted excess returns, (2) market model residuals, (3) excess returns that are measured relative to the CAPM (Sharpe-Lintner residuals), and (4) size-adjusted residuals. In each case, the U.K. Financial Times Actuaries trade-to-trade capitalisation weighted market index as an alternative market proxy was used.

(1) Market-adjusted excess returns are estimated as $\mu_{it} = R_{it} - R_{mt}$.

Security returns, R_t, are dividend-adjusted logarithmic returns taken from the LSPD monthly returns file. R_m, is the trade-to-trade capitalisation weighted Financial Times Actuaries (FTA) all-share market index.

(2) Market model residuals are defined as $\mu_{it} = R_{it} - \alpha_{it} - \beta_{it} R_{mt}$. The parameters α_{it}[9] and β_{it} vary by time t and are estimated by filtering from the previous five years' LSPD return data and by smoothing back from the time five years after time t.

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[8] As concluded by Brown and Warner (1980) that "beyond a simple, one-factor market model, there is no evidence that more complicated methodologies convey any benefits", this empirical study continues to use the four simple models as performance benchmarks in this overreaction study.

[9] Schwert (1983), and Dimson and Marsh (1986) argued that market model alpha estimates may encapsulate any size effect.

Furthermore, to ensure that the trade-to-trade beta estimates were efficient as well as unbiased, Marsh's (1979) weighting scheme was employed (which assumes the variance of the residuals to be approximately proportional to the length of the period) to avoid heteroscedasticity in the residuals. Then, for the purpose of generating cumulative average residuals (CARs) and letting securities be comparable, the transformed residuals were converted to the original residuals by multiplying by the square root of the elapsed time.

(3) Sharpe-Lintner residuals are defined as $\mu_{it} = R_{it} - R_{ft} - \beta_{it}(R_{mt} - R_{ft})$, where the risk-free rate, R_{ft}, was taken as the three-month Treasury Bill rate. The method and procedure of estimating the parameter β_{it} is the same as those in the market model.

(4) Size-adjusted residuals are defined as $\mu_{it} = R_{it} - R_{i(s)t} - (\beta_{it} - \beta_{i(s)t})(R_{mt} - R_{ft})$[10], where $R_{i(s)t}$ is the equally weighted average return[11] over time t on stock i's control portfolio in which all firms have approximately the same capitalisation as firm i, and $\beta_{i(s)t}$ is the CAPM beta of the control portfolio which are computed by regressing returns of the control portfolios of stock i against the trade-to-trade capitalisation

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[10] The abnormal return, μ_{it}, equals the difference between the CAPM-adjusted performance of stock i, $R_{it} - [R_{ft} + \beta_{it}(R_{mt} - R_{ft})]$, and the CAPM-adjusted performance of the control portfolio of stock i, $R_{i(s)t} - [R_{ft} + \beta_{i(s)t}(R_{mt} - R_{ft})]$. This performance measure assumes that excess returns from the CAPM are strongly related to firm size and that $\beta_{i(s)t}$ is only affected by the firm size factor.

[11] Agrawal, Jaffe, and Mandelker (1992) also carried out their tests by redefining $R_{i(s)t}$ as the value-weighted average return over time t on the control portfolio, the results were not significantly different.

weighted FTA all share market index. Stocks were ranked each month according to their market value of equity, and then ten size-based control portfolios were formed.

Except for the capitalisation weighted Financial Times Actuaries (FTA) all-share index collected from Datastream, all data sources were provided by the London Share Price Database (LSPD) from January 1965 to December 1993.

6.7. The Extreme Portfolios Construction and Test

The following procedures similar to those reported by De Bondt and Thaler (1985) were listed to produce residual returns, to form the 'winner' and 'loser' portfolios, and to assess their performance.

(1) For each security i without any missing values between the month 1 and the month 97 and starting in month 61 of the security's return history, the monthly residual returns (μ_{it}) based on the preceding and the following 5 years (120 months) were computed using an α and β estimated from the trade-to-trade and the discounted weighted estimation methods. LSPD returns data were calculated by using month-end transaction prices. A full 60 months of data were required both before and after the residuals computed. The result of this step is a vector of residual returns (μ_{it}) for each security i and typically is 120 months shorter than the vector of the security's returns.

(2) Starting in December 1972 (t=0, the "portfolio formation date"), the cumulative excess returns $CU_i = \Sigma\mu_{it}$ were computed for the prior 36 months (the "portfolio

formation period", including December 1972, the portfolio formation date) for each security, and residual returns must be available for the full 36 months (t<0, the portfolio formation period). For all securities, the CU_t's were ranked from low to high and two portfolios (loser and winner) were formed. Firms in the top 35 stocks were assigned to the winner portfolio, firms in the bottom 35 stocks were assigned to the loser portfolio. Thus, the portfolios are formed conditional upon excess return behaviour prior to the portfolio formation date. This step is repeated 5 times for all nonoverlapping three-year periods between January 1970 and December 1987. The 5 relevant portfolio formation dates are December 1972, December 1975,......, December 1984. For the experiment described above, between 156 and 583 LSPD stocks participate in the various replications.

(3) The portfolio residual returns of all securities in each portfolio for each of the next 36 months, the 'test period' from t=1 to 36 after portfolio formation dates were the average residual returns ($AR_{W,n,t}$ and $AR_{L,n,t}$). And cumulative average residual returns (CARs) were the summation of the AR from month t=1 through month 36.

(4) The last step was using the Standard t, and the Wilcoxon signed tests to assess whether, at any time t>0, there was a statistically significant difference in the performance between loser and winner portfolios, and whether the average residual return (AR) was significantly different from zero. A standard t test was developed under the assumptions that the random variable is normally distributed, the variance of the random variable is chi-square distributed, and they are independent. In more advanced theory and practice, if the distribution is not symmetric and there are outliers,

i e extreme values that deviate greatly from most of the other values, the Wilcoxon sign test in which each extreme value is associated with only one sign and a ranking of its magnitude of the deviation is usually better than that based upon mean value which can be influenced by a few extreme values As explored by Zivney and Thompson (1989), the evidence revealed that the sign test was more powerful than the t-test when applied to market- and risk- adjusted return methodologies The Wilcoxon sign test is a more powerful and more efficient test in many situations Such approaches are referred to as nonparametric or distribution-free methods[12] Finally, a comparison was made between the results of the above procedures for the four different methods of defining residuals

6.8. Summary

The objective of this research is to test whether U K stock market returns revert (overreaction hypothesis) or whether the benchmark models are misspecified. This chapter started with a brief review of the existing evidence on mean reversion and overreaction behaviour in stock markets and provided a preliminary data analysis using the same data as for the previous studies in Chapters 4 and 5 At first sight, the results of the preliminary data analysis seemed to support the market overreaction hypothesis that stocks with the lowest returns (losers) over the portfolio formation period 1980-1982 subsequently outperformed the stocks with the highest returns (winners) over the test period 1983-1985, but market capitalisation effects obscured this conclusion.

[12] The advantages of nonparametric methods are that fewer assumptions are required, and in many cases only nominal (categorised) or ordinal (ranked) data are required, rather than numerical (interval) data

Therefore, firm size effects were considered in the design of this empirical research methodology Finally, data sources and the procedures of the extreme portfolios construction and tests for the overreaction study were provided in this chapter

CHAPTER 7

THE EMPIRICAL RESULTS FOR U.K. THE STOCK MARKET OVERREACTION STUDY

7.1. Introduction

This chapter reports the empirical results for the tests of the long-term overreaction hypothesis described in the previous chapter. Unlike the findings of De Bondt and Thaler (1985) for the U.S. market, the results are sensitive to the four benchmarks used. The structure of the remainder of this chapter is as follows. After adjusting monthly return data for thin trading, allowing parameters to change smoothly through time and the error term to be heteroskedastic, the findings using the four various benchmarks (MR, SMM, SCAPM, and Size and beta) are demonstrated, respectively, in sections 7.2., 7.3., 7.4., and 7.5. Finally, section 7.7. provides a summary relating the findings of the empirical study in this chapter to those of the previous empirical results in chapter 5. The conclusion discusses some implications of these empirical results.

7.2. Results Using Market-Adjusted Excess Returns

This section reports the results for the tests of the overreaction hypothesis by simply using the trade-to-trade capitalisation weighted FTA all-share market index as the benchmark. The findings are closer to those of Kryzanowski and Zhang (1992) for the Canadian market than to those of De Bondt and Thaler (1985) for the U.S. market.

The results reveal continuation behaviour over the first year of the 2, 3, 4-year test periods for winners and losers and reversal behaviour for winners and losers after that The winners measured by performance in the previous five years formation period subsequently underperform the losers which behave insignificantly different from zero for two years at the beginning of the five-year test period and exhibit statistically significant reversal behaviour afterwards

Table 7 1 records the test period's ACARs for winners, losers, and losers-minus-winners of 35 stocks, and their respective test statistics in which both the portfolio formation and the test periods are three years long For the three-year test period, the behaviour of winner and loser portfolios can be divided into three stages In the first stage loser portfolios exhibit reversal behaviour significantly outperforming the winner portfolios. In the second stage, the winner and loser portfolios tend to continue their formation period behaviour until near the end of the first year After the first year of the test period, the winner and loser portfolios exhibit price reversal behaviours: loser portfolios outperform the market by, on average, only 0 1%, at the end of the test period, but winner portfolios, on the other hand, earn about 21.99% less than the market which is statistically significant at the 0.01 level. Thus the difference in cumulative average residuals between the extreme portfolios equals 22.09% Figure 7 1 shows the movement of the ACARs of winners and losers, respectively, through the three-year test period This plot illustrates that the ACARs of loser portfolios of 35 stocks are slightly lower than those of decile portfolios containing about 44 stocks on average The test procedures above are repeated for (extreme 35 stocks and the decile) two different magnitudes of extreme portfolios for two, four, and five-year formation

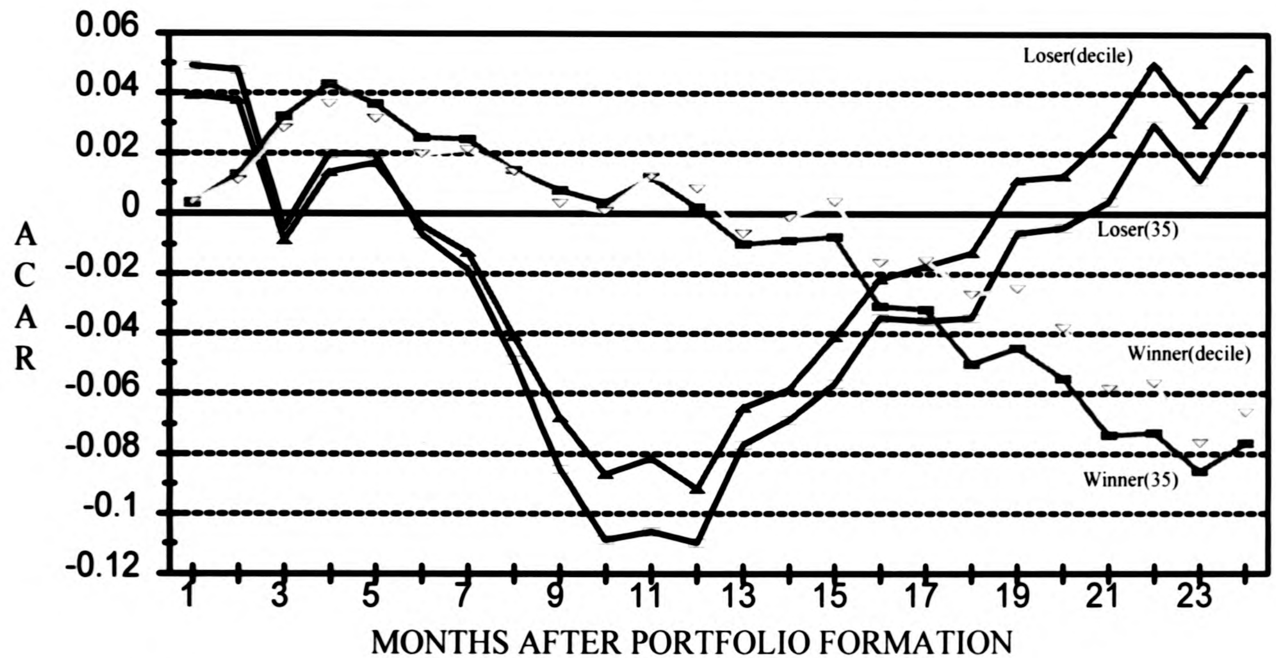
Table 7.1 The Behaviour of ACARs for Losers, Winners, and Losers-Minus-Winners of 35 Stocks over Five Nonoverlapping Three-Year Portfolio Test Periods between January 1973 to December 1987, based on the FTA All-Share Index Benchmark.

Months	Losers (T-Statistics)	Winners (T-Statistics)	L-W (T-Statistics)
1	0.0467	-0.0129	0.0596
	(3.1683)	(-1.9562)	(3.6913)
2	0.0274	-0.0007	0.0280
	(1.3560)	(-0.0785)	(1.2821)
3	-0.0102	0.0019	-0.0121
	(-0.4303)	(0.1703)	(-0.4616)
4	-0.0106	0.0042	-0.0148
	(-0.3741)	(0.2718)	(-0.4587)
5	-0.0253	0.0171	-0.0425
	(-0.8422)	(1.1697)	(-1.2694)
6	-0.0387	0.0234	-0.0621
	(-0.7861)	(1.5567)	(-1.2065)
7	-0.0315	0.0262	-0.0576
	(-0.4750)	(1.4051)	(-0.8375)
8	-0.0580	0.0247	-0.0827
	(-0.7098)	(1.9172)	(-1.0000)
9	-0.0960	0.0037	-0.0997
	(-1.0044)	(0.1647)	(-1.0156)
10	-0.0819	-0.0063	-0.0756
	(-0.8972)	(-0.2395)	(-0.7950)
11	-0.0564	-0.0054	-0.0509
	(-0.6513)	(-0.1449)	(-0.5404)
12	-0.0666	-0.0179	-0.0487
	(-0.7076)	(-0.5263)	(-0.4865)
13	-0.0367	-0.0330	-0.0038
	(-0.4437)	(-0.8864)	(-0.0416)
14	-0.0426	-0.0380	-0.0045
	(-0.4999)	(-0.8097)	(-0.0467)
15	-0.0251	-0.0397	0.0147
	(-0.2687)	(-0.8133)	(0.1391)
16	0.0068	-0.0383	0.0451
	(0.0703)	(-0.7861)	(0.4155)
17	0.0066	-0.0498	0.0564
	(0.0624)	(-0.8766)	(0.4690)
18	-0.0086	-0.0725	0.0640
	(-0.0701)	(-1.1322)	(0.4639)

Table 7.1. -- Continued

19	0.0356	-0.0713	0.1070
	(0.2884)	(-1.0878)	(0.7646)
20	0.0264	-0.0973	0.1237
	(0.2337)	(-1.4599)	(0.9422)
21	0.0364	-0.1272	0.1636
	(0.3030)	(-1.9284)	(1.1944)
22	0.0512	-0.1336	0.1848
	(0.3964)	(-1.8644)	(1.2517)
23	0.0302	-0.1239	0.1541
	(0.2096)	(-1.7501)	(0.9595)
24	0.0254	-0.1317	0.1571
	(0.1823)	(-1.8729)	(1.0055)
25	0.0225	-0.1391	0.1616
	(0.1671)	(-1.8117)	(1.0426)
26	0.0326	-0.1282	0.1607
	(0.2771)	(-1.8376)	(1.1762)
27	0.0305	-0.1243	0.1548
	(0.2544)	(-2.2613)	(1.1734)
28	0.0309	-0.1523	0.1832
	(0.2519)	(-2.4371)	(1.3295)
29	0.0177	-0.1525	0.1702
	(0.1300)	(-2.2685)	(1.1192)
30	0.0273	-0.1672	0.1945
	(0.1841)	(-2.4160)	(1.1889)
31	0.0569	-0.1675	0.2245
	(0.3205)	(-2.6450)	(1.1901)
32	0.0412	-0.1838	0.2250
	(0.2220)	(-2.4762)	(1.1259)
33	0.0154	-0.1838	0.1992
	(0.0821)	(-2.3940)	(0.9820)
34	0.0267	-0.1931	0.2198
	(0.1329)	(-2.4303)	(1.0175)
35	-0.0130	-0.2140	0.2010
	(-0.0723)	(-2.7409)	(1.0241)
36	0.0010	-0.2199	0.2210
	(0.0055)	(-2.8409)	(1.0996)

Figure 7.1. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 5 Three-Year Periods Between January 1973 and December 1987 Using the FTA-All-Share Index as the Benchmark Average.



Note:- Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

and test periods in order to check the consistency over time of the previous findings Table 7 2 , and Figures 7 2, 7 1 , 7 3, and 7 4 present the results for experiments based on portfolio formation and test periods that are, respectively, two, three, four, and five years long These results, unlike those of De Bondt and Thaler (1985), in general do not statistically support the overreaction hypothesis, except for those of the five-year samples (like the findings of Kryzanowski and Zhang (1992) for Canadian market) The difference in the mean CARs between losers and winners of 35 stocks is 39 31% which is statistically significant at the 0 05 level at the end of the test period (the directional effect), and the more extreme the initial price change (portfolios of 35 stocks vs decile portfolios which have about 37 stocks on average) during the formation period (the magnitudinal effect), the more extreme the offsetting reaction over the subsequent test period These findings for the "five-year experiment" correspond with the two propositions, the directional and magnitudinal effects, of the overreaction hypothesis[1]

Use of the market index as the benchmark may introduce noise into the excess return estimates simply because this model assumes that all alphas are equal to zero and all betas are equal to one, which may not be adequate

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[1] The procedures were replicated by redefining excess returns as the size-adjusted residual $\mu_{it} = R_{it} - R_{i(s)t}$, and the findings were not significantly different from the results of using the FTA-all-Share market index as the benchmark

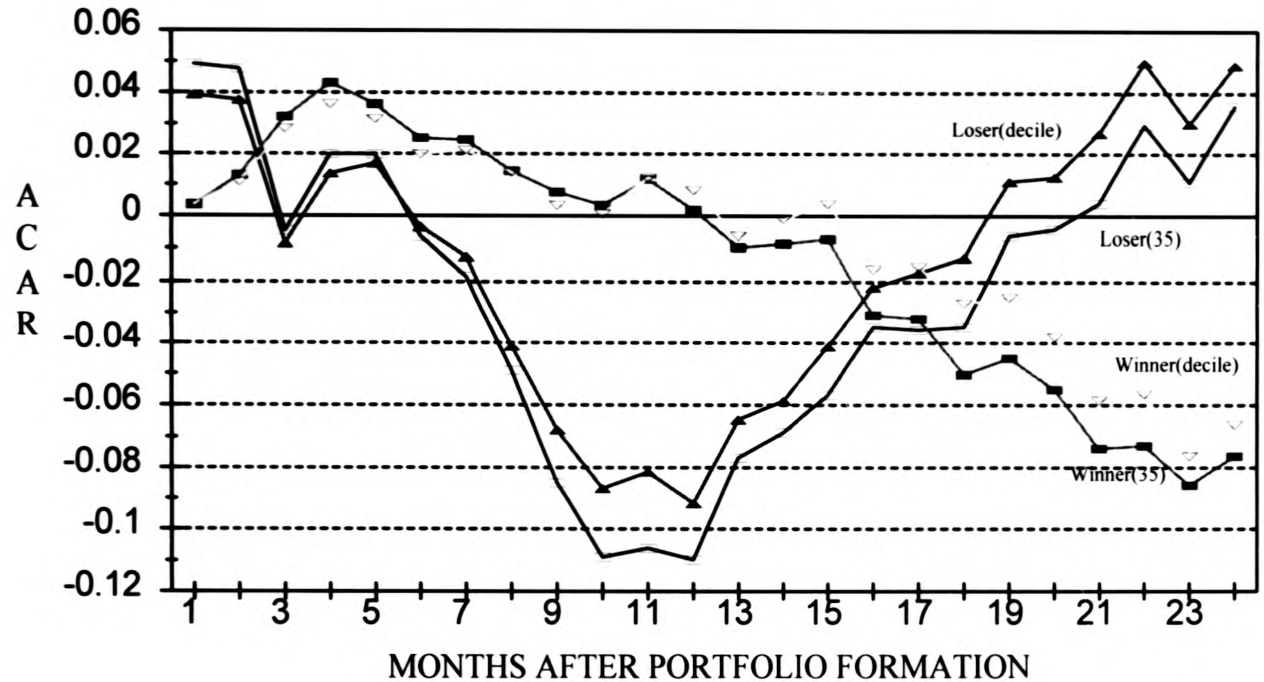
Table 7.2.

Differences In ACAR Between the Loser and Winner Portfolios Using the FTA All-Share Index as the Benchmark

no. of independent replications and length of portfolio formation period	avg. no. of stocks	ACAR at the end of the formation period: winner portfolio	ACAR at the end of the formation period: loser portfolio	Difference in ACAR (T-statistics) {Wilcoxon statistics} Months After Portfolio Formation: 1	12	13	24	25	36	37	48	49	60
3 five-years periods	35	0.8921	-1.1299	0.0988	0.0698	0.01327	0.1191	0.1517	0.2792	0.2926	0.4103	0.4106	0.3931
				(1.4849)	(0.5446)	(0.9887)	(0.6385)	(0.8863)	(1.0657)	(1.0983)	(1.8102)	(1.9173)	(3.3153)
				{ 6 }	{ 4 }	{ 4 }	{4}	{4}	{4}	{4}	{6}	{6}	{6}
3 five-year periods (decile)	37	0.8320	-1.0416	0.0780	0.0560	0.1086	0.0727	0.0986	0.2153	0.2322	0.3682	0.3647	0.3548
				(1.2626)	(0.4281)	(0.8227)	(0.4328)	(0.6047)	(0.8192)	(0.8581)	(1.5987)	(16680)	(2.5448)
				{4}	{4}	{4}	{2}	{4}	{4}	{4}	{6}	{6}	{6}
4 four-year periods	35	0.9944	-1.1572	0.0418	-0.0175	-0.0078	0.1268	0.1754	0.2582	0.2760	0.2647	n.a.	n.a.
				(1.4396)	(-0.1311)	(-0.0596)	(0.9383)	(1.3318)	(1.5439)	(1.7706)	(2.3637)	n.a.	n.a.
				{10}	{0}	{0}	{6}	{6}	{8}	{8}	{8}	n.a.	n.a.
4 four-year periods (decile)	42	0.6989	-1.0882	0.0442	-0.0143	0.0045	0.1316	0.1665	0.2367	0.2646	0.2605	n.a.	n.a.
				(1.4582)	(-0.1081)	(0.0477)	(1.2386)	(1.2801)	(1.3918)	(1.6533)	(2.3301)	n.a.	n.a.
				{10}	{0}	{0}	{6}	{6}	{8}	{8}	{8}	n.a.	n.a.
5 three-year periods	35	0.9628	-1.2668	0.0596	-0.0487	-0.0038	0.1571	0.1616	0.2210	n.a.	n.a.	n.a.	n.a.
				(3.6913)	(-0.4865)	(-0.0416)	(1.0055)	(1.0426)	(1.0996)	n.a.	n.a.	n.a.	n.a.
				{13}	{-1}	{1}	{7}	{9}	{11}	n.a.	n.a.	n.a.	n.a.
5 three-year periods (decile)	44	0.9492	-1.2415	0.0513	-0.0485	-0.0059	0.1814	0.1874	0.2323	n.a.	n.a.	n.a.	n.a.
				(3.1921)	(-1.4786)	-0.0627)	(1.1710)	(1.2408)	(1.2543)	n.a.	n.a.	n.a.	n.a.
				{13}	{-1}	{1}	{7}	{9}	{13}	n.a.	n.a.	n.a.	n.a.
8 two-year periods	35	0.7848	-0.9275	0.0458	-0.1118	-0.0672	0.1122	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				(2.0495)	(-1.3119)	(-0.8455)	(1.0596)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				{28}	{-24}	{-14}	{20}	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
8 two-year periods (decile)	48	0.7114	-0.8305	0.0356	-0.1000	-0.0583	0.1150	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				(1.7255)	(-1.3485)	(-0.8230)	(1.2044)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				{26}	{-28}	{-6}	{22}	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

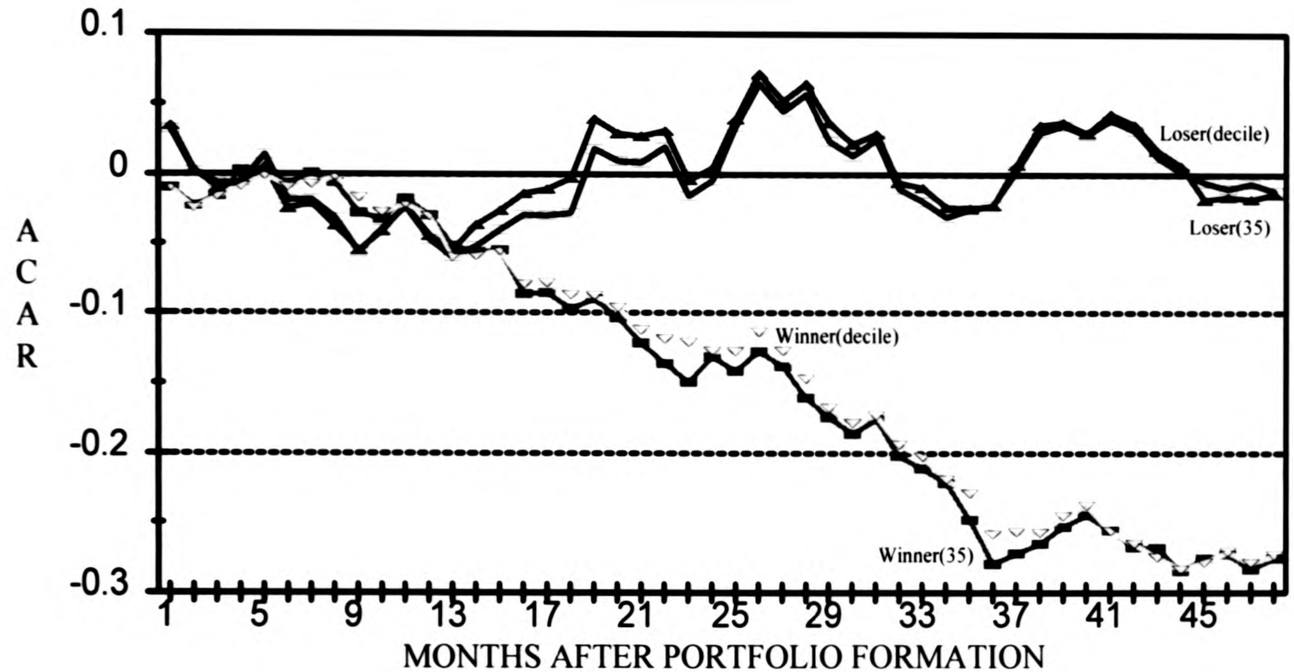
Note:-"a", "b", and "c" represent statistical significance at the 0.10, 0.05, and 0.01 percent levels, respectively.

Figure 7.2. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 8 Two-Year Periods Between January 1972 and December 1987 Using the FTA-All-Share Index as the Benchmark Average.



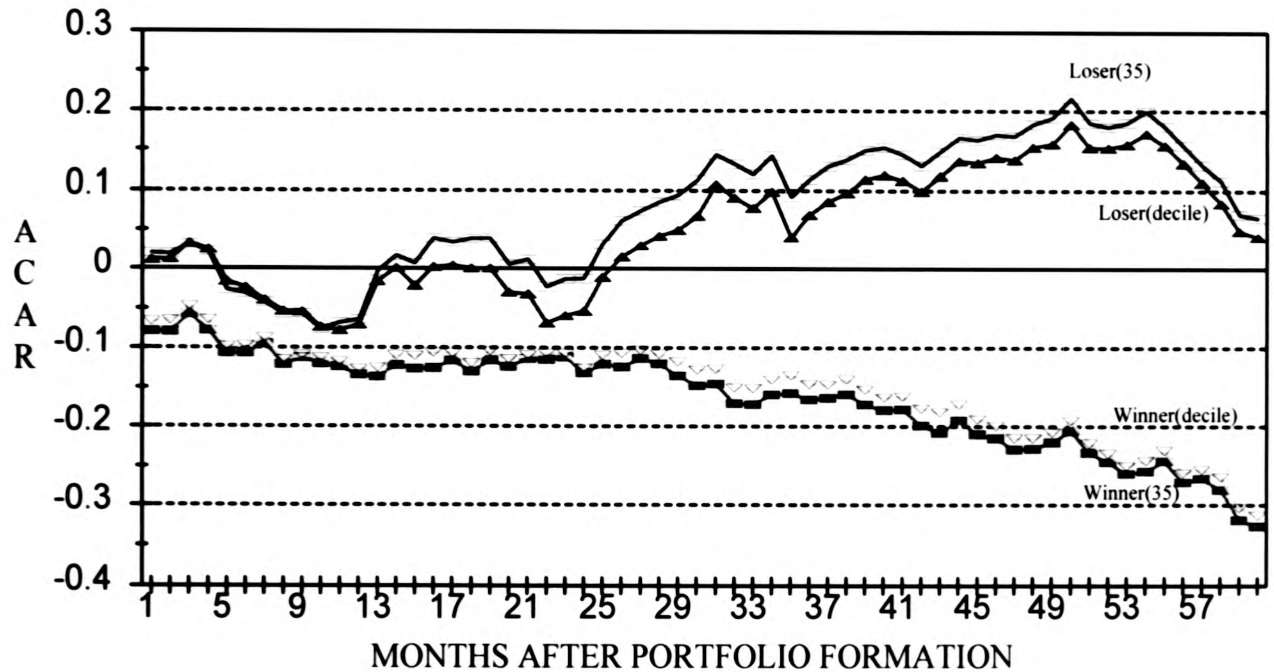
Note:- Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

Figure 7.3. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 4 Four-Year Periods Between January 1974 and December 1989 Using the FTA-All-Share Index as the Benchmark Average



Note:- Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

Figure 7.4. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 3 Five-Year Periods Between January 1975 and December 1989 Using the FTA-All-Share Index as the Benchmark Average.



Note:- Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile

7.3. Results Using the Market Model Residuals

The results of using the market model as the benchmark for four different time period experiments are recorded in Table 7.3., and the movement of the ACAR's of the extreme portfolios both containing 35 stocks and representing decile portfolios for these four experiments is displayed in Figure 7.5., 7.6., 7.7., and 7.8. The findings are somewhat consistent among four different time period experiments, they all seem to be in agreement with the overreaction hypothesis which predicts that the losers will become winners and the winners will become losers.

As reported in Table 7.4. for the three year test period, the ACAR for the winner portfolios is -25.02%, while the ACAR for the loser portfolios equals 27.97% for the extreme portfolios of 35 stocks. When we consider decile portfolios, which contain about 25 stocks on average, the relevant numbers are, respectively, -27.33% and 34.36%. Like the findings of De Bondt and Thaler (1985) for U.S. market, the results using market model residuals have other notable features. First, the reversal behaviour is not symmetric, it is more pronounced in the loser portfolios than in the winner portfolio. Secondly, the more extreme the initial price change (decile portfolios vs. portfolios of 35 stocks) during the formation period, the more extreme the offsetting reaction over the subsequent test period. Thirdly, there is a significant January effect for losing stocks.

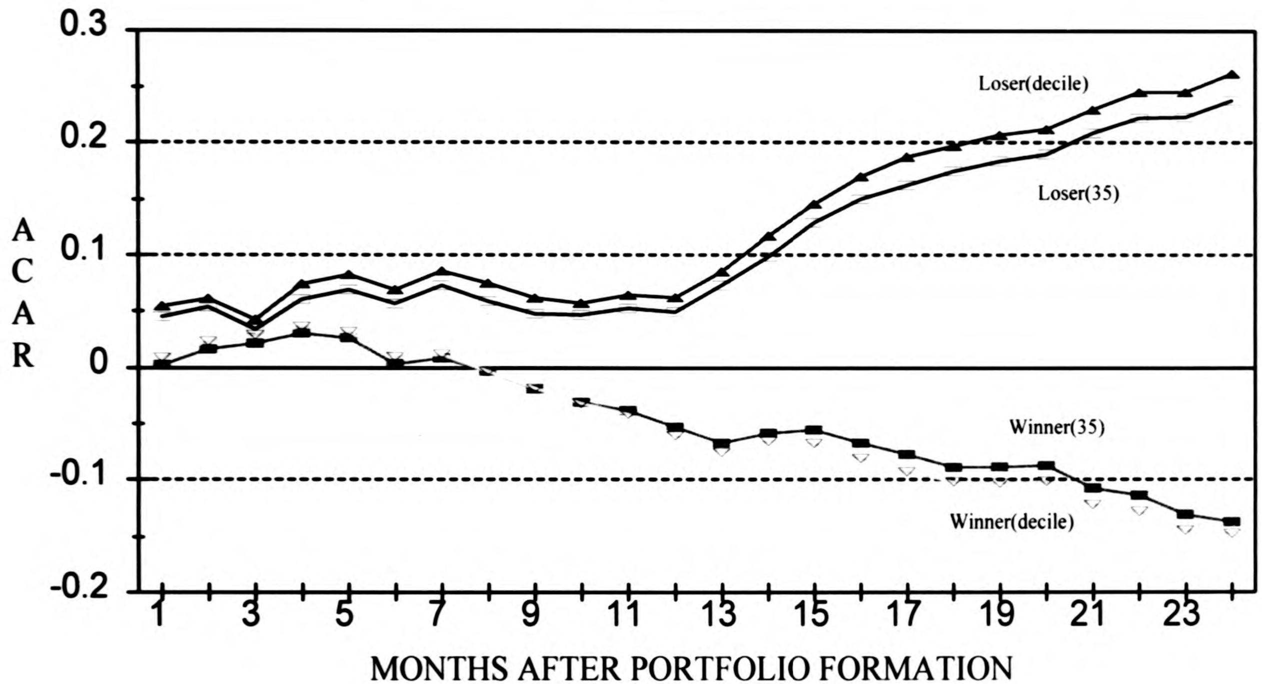
Generally speaking, the results of the four different time period experiments are consistent (see Table 7.3.). Via careful analysis and then assuming that the market

Table 7.3.
Differences in ACAR Between the Loser and Winner Portfolios
Using the Market Model as the Benchmark.

no. of independent replications and length of portfolio formation period	avg. no. of stocks	ACAR at the end of the formation period: winner portfolio	ACAR at the end of the formation period: loser portfolio	Difference in ACAR (T-statistics) {Wilcoxon statistics} Months After Portfolio Formation: 1	12	13	24	25	36	37	48	49	60
3 five-year periods		0.4580	-0.5193	0.0275	0.0215	0.2688	0.3966	0.3882	0.4816	0.4855	0.5192	0.5032	0.4639
				(0.8453)	(4.4018)	(4.3556)	(5.2303)	(6.1317)	(4.6415)	(4.2632)	(4.2442)	(4.3627)	(4.9007)
				{6}	{6}	{6}	{6}	{6}	{6}	{6}	{6}	{6}	{6}
3 five-year periods (decile)	19	0.5906	-0.6405	0.0492	0.2772	0.2754	0.4806	0.4535	0.5631	0.5781	0.5931	0.5741	0.5722
				(1.3034)	(4.2150)	(3.7934)	(4.7427)	(6.0192)	(4.1075)	(3.9142)	(3.9173)	(3.8745)	(4.8093)
				{6}	{6}	{6}	{6}	{6}	{6}	{6}	{6}	{6}	{6}
4 four-year periods	35	0.5656	-0.5279	0.0699	0.2598	0.2827	0.4777	0.5047	0.6439	0.6402	0.6141	n.a.	n.a.
				(2.6199)	(4.2033)	(4.0152)	(4.1413)	(4.5241)	(5.4968)	(6.1786)	(5.8398)	n.a.	n.a.
				{10}	{10}	{10}	{10}	{10}	{10}	{10}	{10}	n.a.	n.a.
4 four-year periods (decile)	23	0.6692	-0.6230	0.0738	0.3206	0.3609	0.6017	0.6280	0.7761	0.7736	0.6921	n.a.	n.a.
				(2.4949)	(4.3121)	(3.6524)	(4.6441)	(4.8118)	(6.0000)	(6.9340)	(6.8466)	n.a.	n.a.
				{10}	{10}	{10}	{10}	{10}	{10}	{10}	{10}	n.a.	n.a.
5 three-year periods	35	0.5693	-0.4930	0.0508	0.1453	0.1854	0.3753	0.4101	0.5299	n.a.	n.a.	n.a.	n.a.
				(2.7323)	(3.4507)	(3.5428)	(4.0281)	(3.8065)	(3.8258)	n.a.	n.a.	n.a.	n.a.
				{13}	{13}	{15}	{15}	{15}	{15}	n.a.	n.a.	n.a.	n.a.
5 three-year periods (decile)	25	0.6639	-0.6703	0.0658	0.1841	0.2262	0.4727	0.4964	0.6169	n.a.	n.a.	n.a.	n.a.
				(3.6044)	(4.2641)	(4.3201)	(4.7733)	(4.2515)	(4.4242)	n.a.	n.a.	n.a.	n.a.
				{13}	{15}	{15}	{15}	{15}	{15}	n.a.	n.a.	n.a.	n.a.
8 two-year periods	35	0.5475	-0.5422	0.0423	0.1022	0.1402	0.3746	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				(2.1631)	(1.8786)	(2.4799)	(6.1403)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				{30}	{30}	{36}	{36}	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
8 two-year periods (decile)	28	0.5955	-0.5935	0.0453	0.1225	0.1606	0.4097	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				(2.0952)	(2.0011)	(2.5034)	(6.0319)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				{30}	{30}	{30}	{36}	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

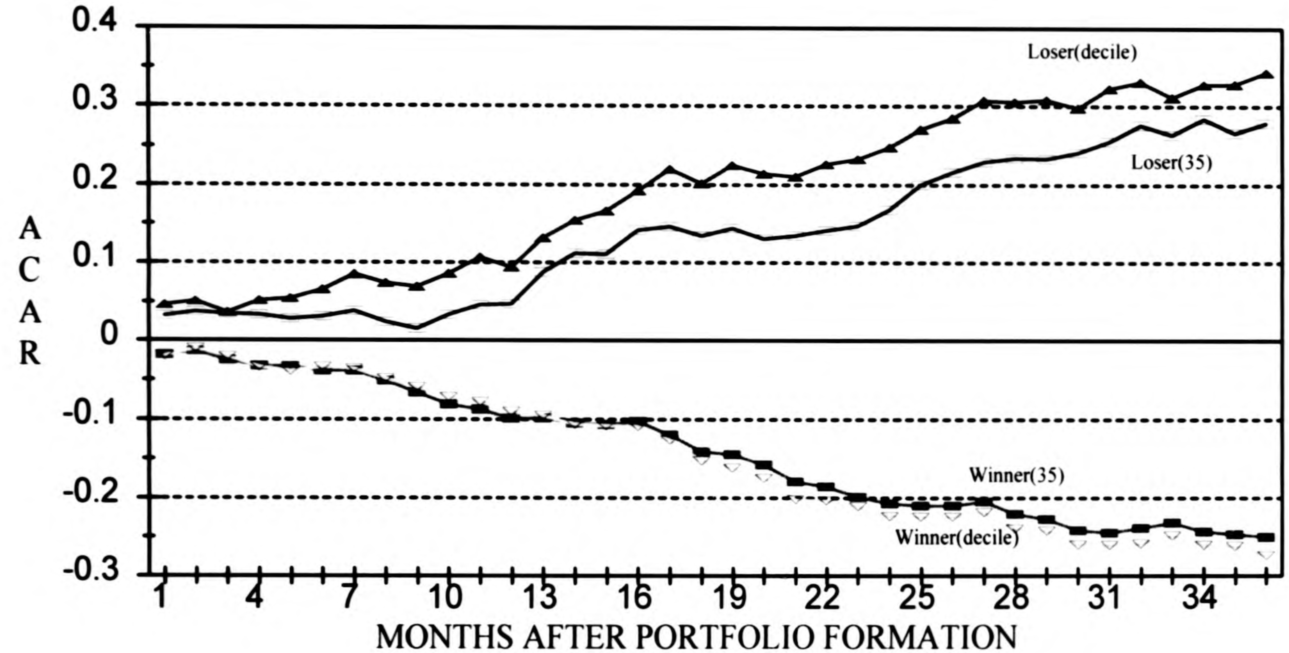
Note:-"a", "b", and "c" represent statistical significance at the 0.10, 0.05, and 0.01 percent levels, respectively.

Figure 7.5. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 8 Two-Year Periods Between January 1972 and December 1987 Using the Market Model as the Benchmark Average.



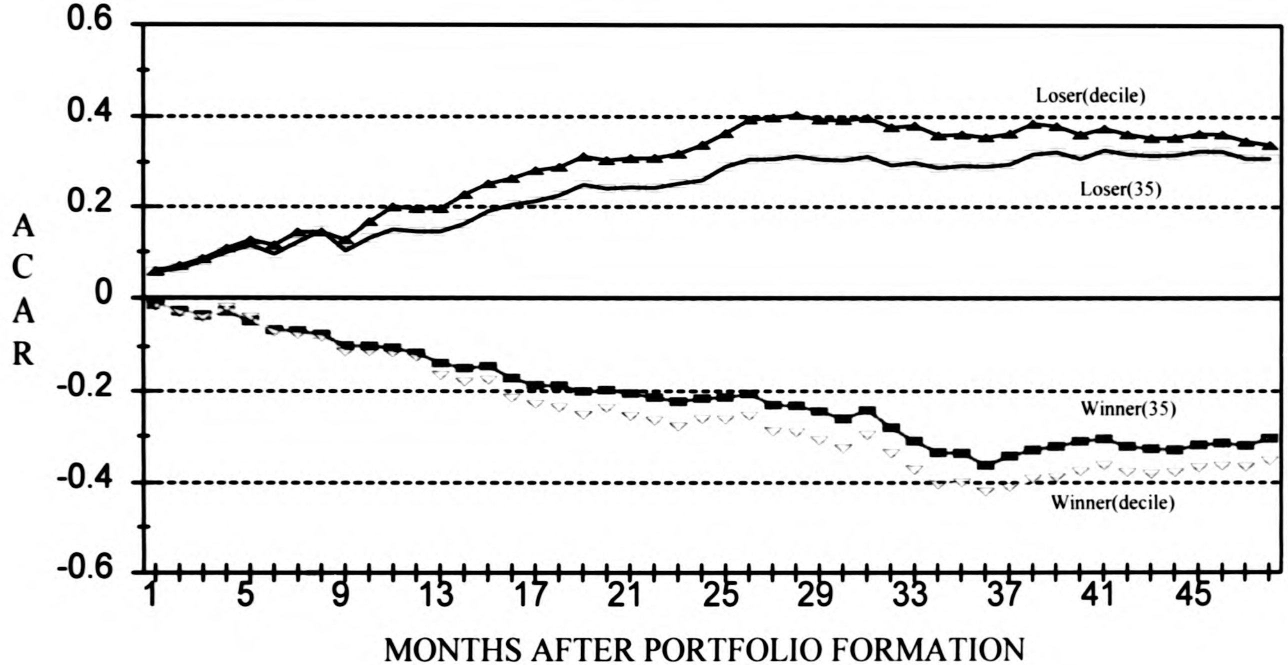
Note:- Loser(35) represents loser portfolio of 35 stocks,
Winner(35) represents winner portfolio of 35 stocks,
Loser(decile) represents loser portfolio of decile,
Winner(decile) represents winner portfolio of decile.

Figure 7.6. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 5 Three-Year Periods Between January 1973 and December 1987 Using the Market Model as the Benchmark Average



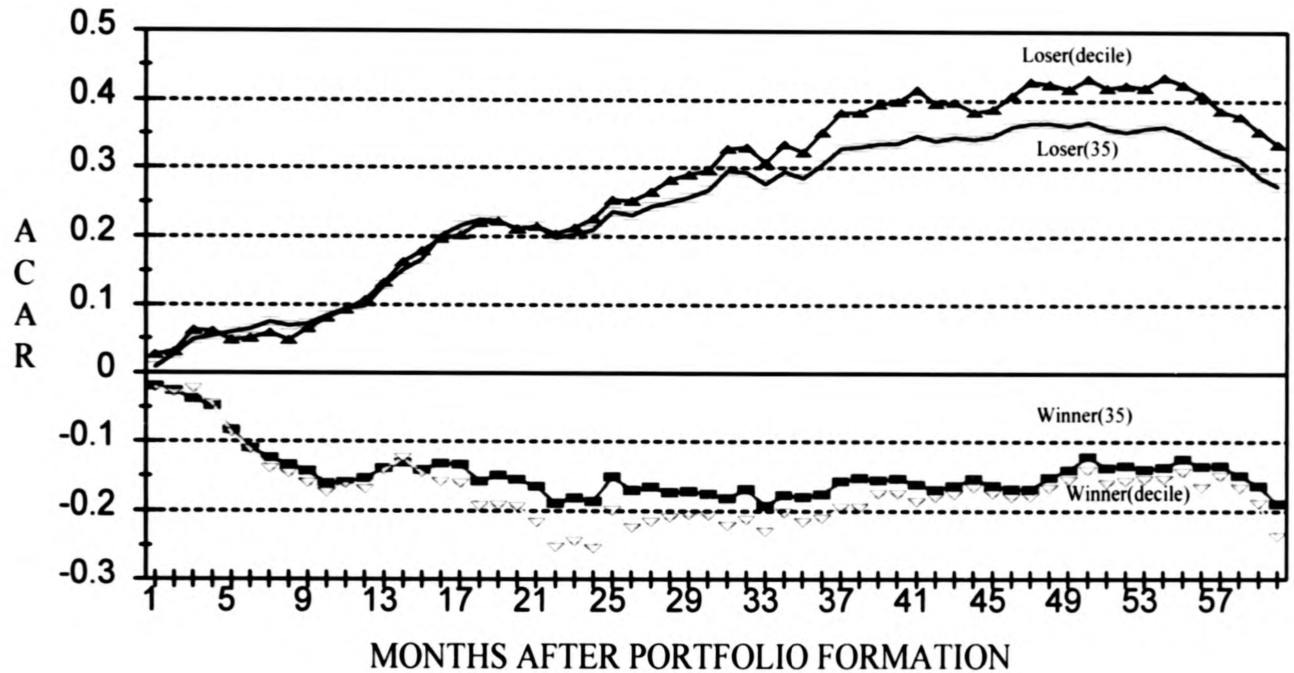
Note - Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

Figure 7.7. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 4 Four-Year Periods Between January 1974 and December 1989 Using the Market Model as the Benchmark Average.



Note:- Loser(35) represents loser portfolio of 35 stocks,
Winner(35) represents winner portfolio of 35 stocks,
Loser(decile) represents loser portfolio of decile,
Winner(decile) represents winner portfolio of decile.

Figure 7.8. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 3 Five-Year Periods Between January 1975 and December 1989 Using the Market Model as the Benchmark Average.



Note: - Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

Table 7.4 The Behaviour of ACAR's for Losers, Winners, and Losers-Minus-Winners of 35 Stocks over Five Nonoverlapping Three-Year Portfolio Test Periods Between January 1973 to December 1987, Based on the Market Model Benchmark

Months	Losers (T-Statistics)	Winners (T-Statistics)	L-W (T-Statistics)
1	0.0319	-0.0189	0.0508
	(1.9233)	(-2.2450)	(2.7323)
2	0.0373	-0.0139	0.0512
	(1.5382)	(-2.0513)	(2.0349)
3	0.0343	-0.0255	0.0598
	(1.7388)	(-3.9230)	(2.8766)
4	0.0333	-0.0331	0.0664
	(1.8630)	(-4.2888)	(3.4091)
5	0.0279	-0.0336	0.0615
	(1.5378)	(-3.9362)	(3.0643)
6	0.0309	-0.0390	0.0699
	(1.6563)	(-2.4745)	(2.8624)
7	0.0380	-0.0391	0.0771
	(1.2657)	(-2.4775)	(2.2732)
8	0.0239	-0.0514	0.0752
	(0.9336)	(-2.6207)	(2.3350)
9	0.0153	-0.0662	0.0815
	(0.3694)	(-4.2849)	(1.8452)
10	0.0334	-0.0810	0.1144
	(0.7566)	(-5.8903)	(2.4731)
11	0.0460	-0.0873	0.1333
	(1.1812)	(-10.6181)	(3.3504)
12	0.0470	-0.0983	0.1453
	(1.1521)	(-9.3048)	(3.4507)
13	0.0877	-0.0978	0.1854
	(1.9073)	(-3.9059)	(3.5428)
14	0.1118	-0.1045	0.2163
	(2.4011)	(-4.0391)	(4.0611)
15	0.1107	-0.1063	0.2170
	(2.4900)	(-4.7679)	(4.3641)
16	0.1418	-0.1019	0.2436
	(2.8488)	(-5.3140)	(4.5685)
17	0.1460	-0.1189	0.2649
	(2.5646)	(-4.6276)	(4.2416)
18	0.1339	-0.1409	0.2748
	(2.2556)	(-4.6731)	(4.1268)

Table 7.4 -- Continued

19	0.1437	-0.1444	0.2881
	(2.6640)	(-4.2326)	(4.5138)
20	0.1304	-0.1575	0.2878
	(2.5101)	(-3.9464)	(4.3946)
21	0.1342	-0.1792	0.3134
	(2.3286)	(-3.9655)	(4.2794)
22	0.1413	-0.1855	0.3268
	(2.1860)	(-4.1530)	(4.1597)
23	0.1470	-0.1986	0.3456
	(2.0483)	(-3.8424)	(3.9077)
24	0.1678	-0.2074	0.3753
	(2.3768)	(-3.4133)	(4.0281)
25	0.2003	-0.2098	0.4101
	(2.5808)	(-2.8076)	(3.8065)
26	0.2166	-0.2099	0.4265
	(3.0938)	(-2.7595)	(4.1256)
27	0.2299	-0.2048	0.4347
	(3.2287)	(-3.5501)	(4.7434)
28	0.2347	-0.2207	0.4554
	(3.1034)	(-2.8064)	(4.1740)
29	0.2337	-0.2273	0.4611
	(3.0642)	(-2.6541)	(4.0199)
30	0.2418	-0.2418	0.4836
	(2.8598)	(-2.7639)	(3.9748)
31	0.2563	-0.2450	0.5012
	(2.5057)	(-2.4847)	(3.5284)
32	0.2763	-0.2385	0.5148
	(2.6906)	(-2.3554)	(3.5697)
33	0.2648	-0.2321	0.4969
	(2.6082)	(-2.3451)	(3.5046)
34	0.2843	-0.2434	0.5276
	(2.7227)	(-2.4235)	(3.6423)
35	0.2668	-0.2469	0.5138
	(2.6333)	(-2.7117)	(3.7712)
36	0.2797	-0.2502	0.5299
	(2.6702)	(-2.7609)	(3.8258)

model is not misspecified. De Bondt (1985), in his Ph D dissertation, raised two possible sources of measurement error, the parameters' updating procedure and the portfolios grouping procedure We may look back to the simple example mentioned in section 6 5 in order to have some idea of what the measurement error induced by those two procedures might be Indeed, De Bondt argued " Consider the companies in the winner portfolio The large positive excess returns that characterise these firms over the formation period affect the estimated market model parameters used to predict the expected returns during the test period ..." (p71, 1985) For instance, in Table 6 2, using the estimated FMM α 's (historical alphas) which were simply estimated by filtering over the previous five years' LSPD return data may introduce considerable noise They monotonously increase over the formation period for the winner portfolio and decrease for the loser portfolio These findings are consistent with "updating bias" which may bias the results in favour of the overreaction hypothesis As to the portfolios' grouping procedure, De Bondt gave an explanation "Assume that, due to random sampling error, the alpha and/or beta of a particular company is underestimated Then the residual returns during the formation period will be inflated As a result, the security may inappropriately be classified into the winner portfolio (and conversely, into the loser portfolio if alpha and/or beta is overestimated)." (p72 1985) Again, both the average FMM alphas and betas which are used to compute the residual returns over the formation period, in Panel A of Table 6 2, are smaller for the winner portfolios ($\bar{\alpha}$ = 0 0065 and $\bar{\beta}$ = 0 8332) than for the loser portfolios ($\bar{\alpha}$ = 0 0309 and $\bar{\beta}$ = 2 1432), this evidence is consistent with the "portfolio formation bias" This evidence is consistent with that represented in Ball, Kothari, and Shanken (1995) They stated that "... much of the reported profitability of a contrarian strategy is driven by low-priced loser stocks" (p104 1995), " For example, loser-stock return distributions are highly right-skewed " (p80 1995)

In order to remove the updating bias, De Bondt (1985) suggested estimating the parameters α and β only once over an initial five-year period, and using the estimates through the following formation and test periods. Although his simple method may prevent the updating bias, it is inconsistent with the fact that estimated betas change over time. In this dissertation, the parameters are estimated by both filtering from the previous five years and smoothing back from the time five years after time t. Comparing this method with simply filtering (the results are reported in Table 6.2), the estimated SMM α's for the winner portfolio no longer have a tendency to increase during the formation period and the estimated SMM α's for the loser portfolio have no tendency to decrease.

Although the smoothing method has proven to have higher predictive ability, the portfolio formation bias will still exist as long as the expected values are estimated. Therefore, we still cannot conclude that the results of this section support the overreaction hypothesis. Thus, in the next subsection we employ the CAPM as the benchmark to calculate residuals. In the CAPM, the estimated α will be substituted by the formula $R_f(1-\beta)$, and thus only one parameter, beta, needs to be estimated. Consequently, the updating procedure can be dropped, and the portfolio formation bias may be reduced.

7.4. Results Using Sharpe-Lintner Residuals

The results based on the CAPM benchmark are presented in Tables 7.5., the three-year test period ACARs for winners, losers, and loser-minus-winners of 35 stocks are presented in Table 7.6. The movements of the ACARs of the extreme portfolios each containing 35 stocks and representing decile portfolios for the four experiments are displayed in Figure 7.9~7.12. Except at the beginning of the test period at which the loser portfolio, for two, three, and four-year portfolio/test periods, significantly outperform the winner portfolios, none of them achieve statistically significant outperformance over the rest of the test periods. For the five-year experiment, the winner and the loser portfolios even exhibit continuation behaviour over the test period.

Unlike the consistent overreaction behaviour for the extreme portfolios based on the market model residuals for different subperiods, the results using the CAPM residuals show non-uniformity for different subperiods. (see Table 7.7.) The loser portfolios underperform the winner portfolios for the first three test subperiods, but the loser portfolios outperform the winner portfolios for the last two test subperiods. In order to allow for market capitalisation effects, (as in the simple example in section 6.5.), the next subsection will use the size-adjusted excess returns to account for the firm size effect and compare the results with those using Sharpe-Lintner residuals in this section.

Table 7.5.

Differences in ACAR Between the Loser and Winner Portfolios

Using the CAPM as the Benchmark.

no. of independent replications and length of portfolio formation period	avg. no. of stocks	ACAR at the end of the formation period: winner portfolio	loser portfolio	Difference in ACAR (T-statistics) {Wilcoxon statistics} Months After Portfolio Formation: 1	12	13	24	25	36	37	48	49	60
3 five-years periods	35	0.7073	-0.8634	-0.0413	-0.1384	-0.1130	-0.1181	-0.1470	-0.1868	-0.1720	-0.1693	-0.1748	-0.2297
				(-0.8431)	(-1.2926)	(-1.0676)	(-0.8486)	(-1.1639)	(-0.9950)	(-0.9193)	(-0.7994)	(-0.8559)	(-1.1225)
				{-2}	{-4}	{-4}	{-4}	{-4}	{-4}	{-2}	{-2}	{-2}	{-2}
3 five-year periods (decile)	19	0.0280	-1.0807	-0.0280	-0.1617	-0.1498	-0.2039	-0.2424	-0.3285	-0.3073	-0.2794	-0.2938	-0.3295
				(-0.3654)	(-1.1511)	(-0.9633)	(-1.0624)	(-1.4228)	(-1.2928)	(-1.1994)	(-0.9782)	(-1.0551)	(-1.3297)
				{0}	{-4}	{-4}	{-4}	{-4}	{-4}	{-4}	{-2}	{-4}	{-4}
4 four-year periods	35	0.7585	-0.8089	0.0524	0.0104	-0.0216	-0.0130	0.0137	0.0310	0.0087	-0.1223	n.a.	n.a.
				(2.4320)	(0.2255)	(-0.3887)	(-0.1192)	(0.1259)	(0.1954)	(0.0575)	(-0.6975)	n.a.	n.a.
				{10}	{0}	{-4}	{-2}	{2}	{2}	{0}	{-4}	n.a.	n.a.
4 four-year periods (decile)	23	0.8946	-0.9627	0.0646	0.0358	0.0251	0.0384	0.0649	0.0884	0.0511	-0.1043	n.a.	n.a.
				(2.3254)	(0.9969)	(0.8599)	(0.5031)	(0.8514)	(0.6327)	(0.3754)	(-0.6155)	n.a.	n.a.
				{10}	{4}	{8}	{4}	{6}	{4}	{2}	{-4}	n.a.	n.a.
5 three-year periods	35	0.6974	-0.7784	0.0539	-0.0029	0.0021	0.0151	0.0024	-0.0009	n.a.	n.a.	n.a.	n.a.
				(3.6882)	(-0.0807)	(0.0433)	(0.1899)	(0.0121)	(-0.0077)	n.a.	n.a.	n.a.	n.a.
				{15}	{1}	{3}	{-1}	{3}	{-1}	n.a.	n.a.	n.a.	n.a.
5 three-year periods (decile)	25	0.8028	-0.8974	0.0556	0.0134	0.0250	0.0393	0.0254	0.0339	n.a.	n.a.	n.a.	n.a.
				(3.0835)	(0.3301)	(0.4146)	(0.4157)	(0.2251)	(0.2158)	n.a.	n.a.	n.a.	n.a.
				{13}	{3}	{3}	{5}	{1}	{3}	n.a.	n.a.	n.a.	n.a.
8 two-year periods	35	0.6219	-0.6608	0..336	-0.0323	-0.0275	0.0516	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				(1.7931)	(-0.5610)	(-0.5067)	(0.8418)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				{26}	{-16}	{-14}	{26}	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
8 two-year periods (decile)	28	0.6800	-0.7190	0.0386	-0.0366	-0.0362	0.0520	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				(1.9885)	(-0.7191)	(-0.7269)	(0.8899)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				{30}	{-18}	{-18}	{26}	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note:-"a", "b", and "c" represent statistical significance at the 0.10, 0.05, and 0.01 percent levels, respectively.

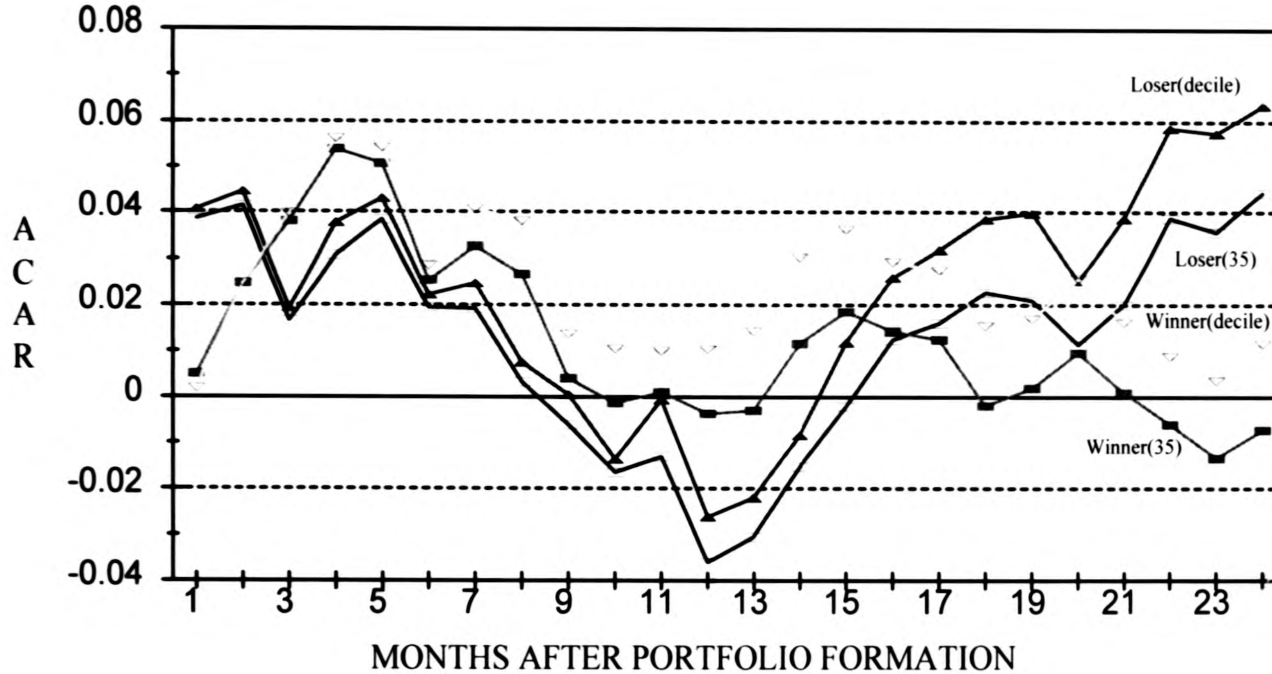
Table 7.6 The Behaviour of ACAR's for Losers, Winners, and Loser-Minus-Winners of 35 Stocks Over Five Nonoverlapping Three-Year Portfolio Test Periods Between January 1973 to December 1987, Based on the CAPM Benchmark

Months	Losers (T-Statistics)	Winners (T-Statistics)	L-W (T-Statistics)
1	0.0334	-0.0205	0.0539
	(2.7082)	(-2.6147)	(3.6882)
2	0.0441	-0.0067	0.0508
	(2.9000)	(-0.8986)	(2.9993)
3	0.0179	-0.0025	0.0204
	(0.7700)	(-0.3907)	(0.8453)
4	0.0193	-0.0050	0.0243
	(0.7400)	(-1.5744)	(0.9238)
5	0.0139	0.0017	0.0122
	(0.5254)	(0.3710)	(0.4551)
6	0.0171	-0.0106	0.0276
	(0.6725)	(-0.9020)	(0.9885)
7	0.0173	0.0012	0.0161
	(0.7398)	(0.1405)	(0.6425)
8	-0.0042	0.0113	-0.0155
	(-0.1465)	(1.2343)	(-0.5194)
9	-0.0176	-0.0048	-0.0128
	(-0.4739)	(-0.4846)	(-0.3330)
10	-0.0034	-0.0142	0.0107
	(-0.0886)	(-0.9286)	(0.2570)
11	-0.0035	-0.0061	0.0025
	(-0.1083)	(-0.8876)	(0.0765)
12	-0.0184	-0.0154	-0.0029
	(-0.5491)	(-1.0754)	(-0.0807)
13	-0.0048	-0.0069	0.0021
	(-0.1268)	(-0.2283)	(0.0433)
14	0.0186	-0.0019	0.0205
	(0.4645)	(-0.0811)	(0.4427)
15	0.0226	0.0015	0.0211
	(0.5484)	(0.0680)	(0.4515)
16	0.0309	0.0147	0.0161
	(0.6556)	(0.6044)	(0.3045)
17	0.0364	0.0117	0.0247
	(0.7213)	(0.5501)	(0.4513)
18	0.0047	-0.0119	0.0166
	(0.0848)	(-0.4787)	(0.2737)

Table 7 6 -- Continued

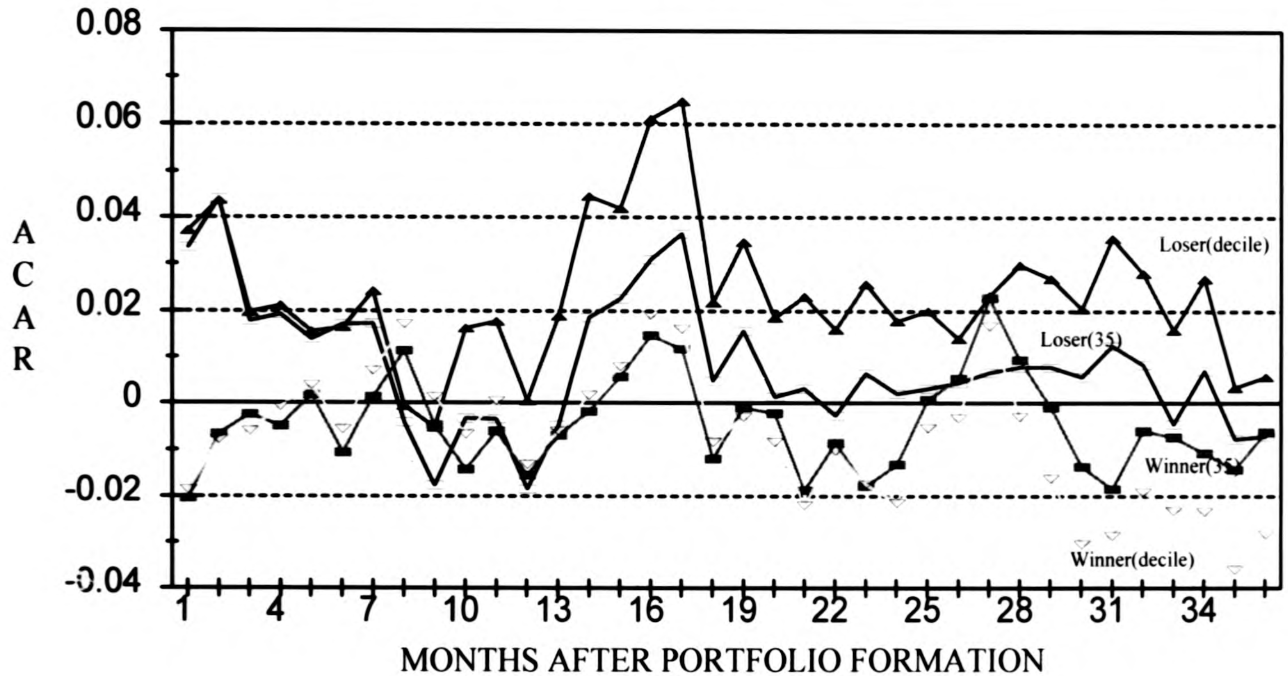
19	0 0157	-0 0011	0 0168
	(0 2747)	(-0 0503)	(0 2745)
20	0 0013	-0 0023	0 0036
	(0 0235)	(-0 0809)	(0 0591)
21	0 0031	-0 0187	0 0218
	(0 0550)	(-0 5132)	(0 3252)
22	-0 0028	-0 0085	0 0057
	(-0 0514)	(-0 2323)	(0 0871)
23	0 0081	-0 0178	0 0259
	(0 1350)	(-0 4331)	(0 3556)
24	0 0020	-0 0131	0 0151
	(0 0338)	(-0 2525)	(0 1899)
25	0 0031	0 0007	0 0024
	(0 0401)	(0 0113)	(0 0251)
26	0 0043	0 0052	-0 0009
	(0 0598)	(0 0812)	(-0 0089)
27	0 0064	0 0228	-0 0164
	(0 0876)	(0 4765)	(-0 1871)
28	0 0077	0 0093	-0 0016
	(0 1000)	(0 1579)	(-0 0162)
29	0 0077	-0 0010	0 0086
	(0 0977)	(-0 0138)	(0 0822)
30	0 0055	-0 0136	0 0190
	(0 0587)	(-0 1847)	(0 1603)
31	0 0124	-0 0184	0 0308
	(0 1165)	(-0 2462)	(0 2366)
32	0 0082	-0 0060	0 0142
	(0 0700)	(-0 0750)	(0 1001)
33	-0 0045	-0 0073	0 0028
	(-0 0400)	(-0 0890)	(0 0203)
34	0 0069	-0 0107	0 0176
	(0 0560)	(-0 1300)	(0 1189)
35	-0 0077	-0 0142	0 0065
	(-0 0663)	(-0 1724)	(0 0456)
36	-0 0071	-0 0062	-0 0009
	(-0 0635)	(-0 0720)	(-0 0064)

Figure 7.9. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 8 Two-Year Periods Between January 1972 and December 1987Using the CAPM as the Benchmark Average.



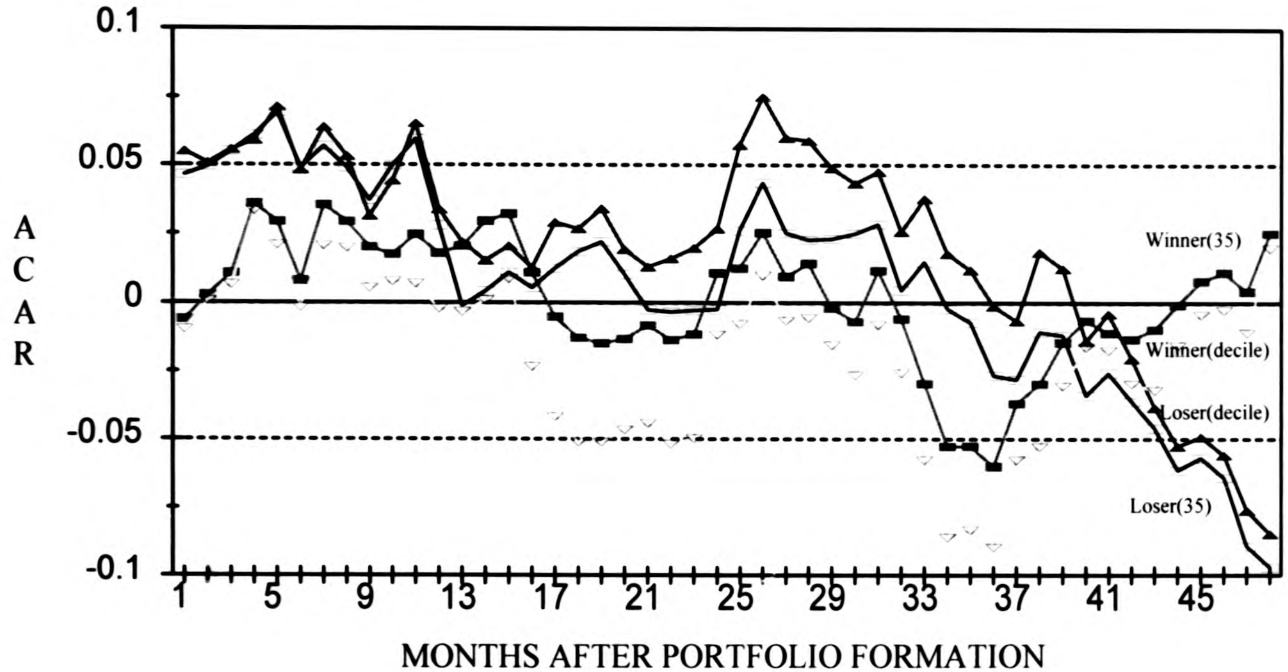
Note:- Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

Figure 7.10. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 5 Three-Year Periods Between January 1973 and December 1987 Using the CAPM as the Benchmark Average.



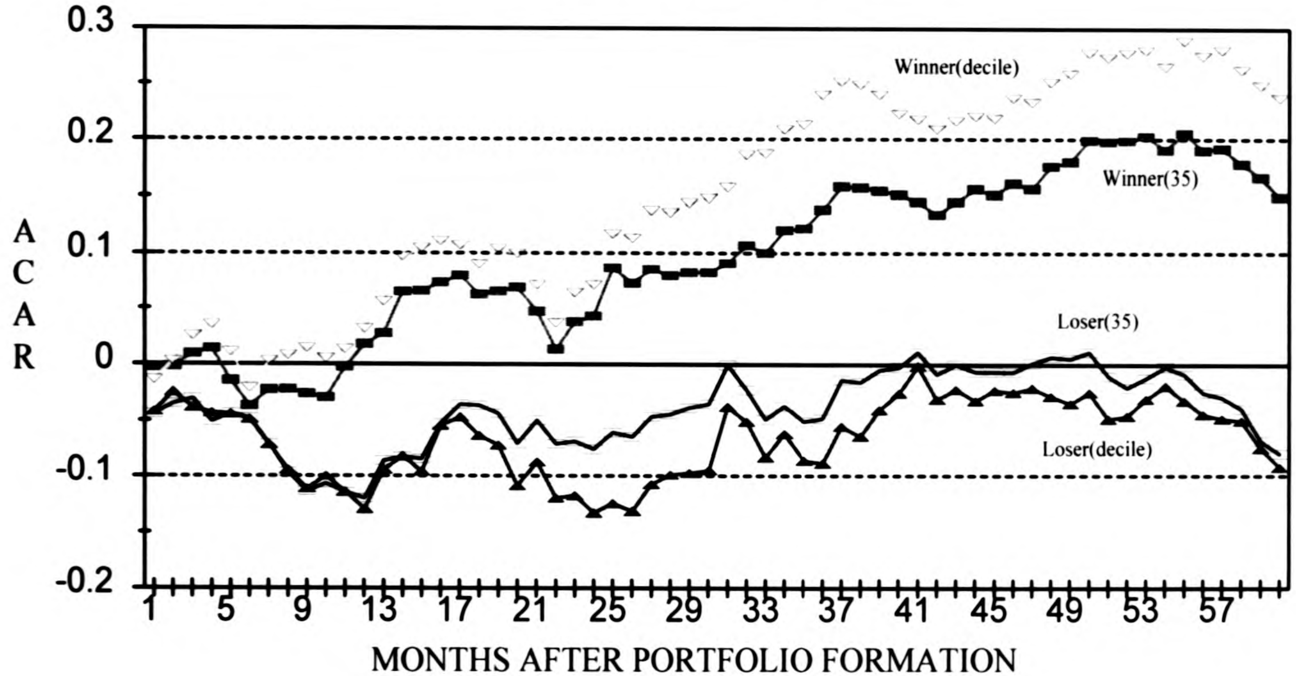
Note:- Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

Figure 7.11. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 4 Four-Year Periods Between January 1974 and December 1989 Using the CAPM as the Benchmark Average.



Note:- Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

Figure 7.12. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 3 Five-Year Periods Between January 1975 and December 1989 Using the CAPM as the Benchmark Average.



Note:- Loser(35) represents loser portfolio of 35 stocks,
Winner(35) represents winner portfolio of 35 stocks,
Loser(decile) represents loser portfolio of decile,
Winner(decile) represents winner portfolio of decile.

Table 7.7.
Cumulative Average CAPM Residuals (%)
for Winner and Loser Portfolios over Three-Year Portfolio Test Periods.

		Panel A:							Panel B:						
		Portfolios of 35 stocks							Decile Portfolios						
periods	**month**	0	6	12	18	24	30	36	0	6	12	18	24	30	36
Jan. 1974 ~	Winners	91.61	3.10	-6.41	-10.24	-18.26	-22.91	-17.01	98.42	2.45	-9.17	-11.46	-23.51	-30.43	-25.04
Dec. 1976	Losers	-69.26	8.58	-1.05	1.77	-1.4	-18.51	-27.06	-79.67	9.76	1.96	6.35	2.47	-13.62	-21.82
	L - W		5.48	5.36	12.01	16.86	4.40	-10.05		7.31	11.13	17.81	25.98	16.81	3.22
Jan. 1977 ~	Winners	62.57	-3.31	-2.95	3.26	12.50	12.01	17.86	75.15	-0.28	3.15	8.62	20.06	22.52	28.41
Dec. 1979	Losers	-103.63	-1.15	-6.37	-2.92	5.96	9.12	11.68	-127.56	-0.11	-4.50	-5.22	3.68	5.97	9.14
	L - W		2.16	-3.42	-6.18	-6.54	-2.89	-6.18		0.17	-7.65	-13.84	-16.38	-16.55	-19.27
Jan. 1980 ~	Winners	74.71	-0.14	-0.34	-0.33	1.54	11.65	10.02	94.25	-0.89	0.09	-0.19	0.07	9.45	9.55
Dec. 1982	Losers	-53.57	-5.04	-3.94	-8.66	-16.43	-20.50	-20.37	-67.11	-5.86	-0.84	-8.10	-15.60	-21.33	-18.51
	L - W		-4.9	-3.6	-8.33	-17.97	-32.15	-30.39		-4.97	-0.93	-7.91	-15.67	-30.78	-28.06
Jan. 1983 ~	Winners	52.83	-2.11	1.79	-2.03	-6.19	-15.04	-25.40	60.00	-1.02	-0.85	-4.89	-8.96	-18.45	-31.65
Dec. 1985	Losers	-78.41	-0.4	-8.44	-8.99	-6.60	2.75	-2.62	-84.80	-2.62	-8.56	-6.36	-4.21	4.12	-4.63
	L - W		1.71	-10.23	-6.96	-0.41	17.79	22.78		-1.6	-7.71	-1.47	4.75	22.57	27.02
Jan. 1986 ~	Winners	67.00	-2.82	0.19	3.38	3.87	7.51	11.43	73.56	-3.13	0.25	3.70	1.60	1.66	4.60
Dec. 1988	Losers	-84.35	6.54	10.61	21.15	19.49	29.88	34.82	-89.55	7.01	12.13	24.23	22.58	35.09	38.62
	L - W		9.36	10.42	17.77	15.62	22.37	23.39		10.14	11.88	20.53	20/98	33.43	34.12

Note - Month 0 is the month of portfolio formation.

7.5. Results Using Size-Adjusted Residuals

The size-adjusted residual of stock i is defined as the difference between the CAPM-adjusted residual of stock i and the CAPM-adjusted residual of the size controlled portfolio of stock i; that is to extract firm size factor from the CAPM-adjusted performance The average cumulative abnormal test period returns for four experiments are presented in the Table 7 8 , and the movement of the ACARs of the extreme portfolios for the two, three, four, and five-year experiments is displayed in Figure 7.13.~7.16. Except the five-year experiment in which the losers continue to lose and the winners continue to win (but they are not significant) For the whole test period (at the end of the test period, the ACAR of the winner portfolios of 35 stocks equals 15.35%, and the ACAR of the loser portfolios equals -5 33%), there are no significant differences between the behaviour of losers and that of winners for the other experiments (see Table 7.9.) Overall, the behaviour patterns of the ACARs based on the size-adjusted residuals of the two extreme portfolios over the test periods are similar to those based on the CAPM residuals, but the values of their respective ACARs are slightly higher In general, the conclusions of no market overreaction are relatively unaffected by tests that account for the firm-size effect.

7.6. Summary and Conclusions

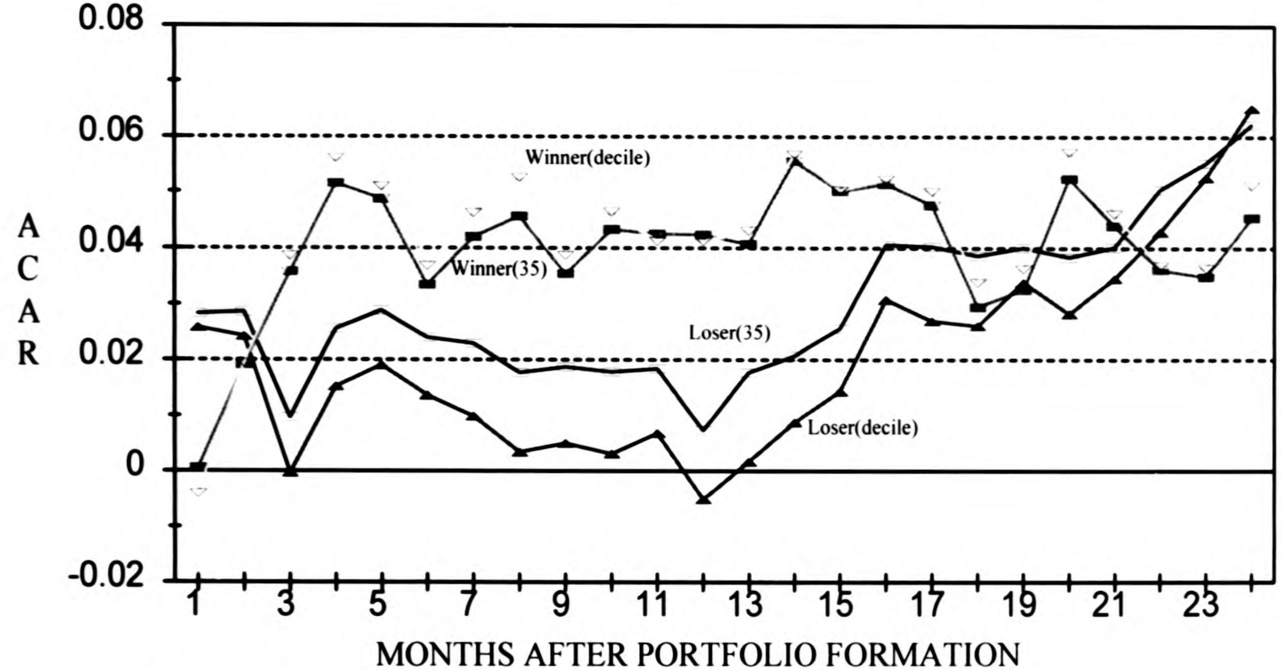
The objective of this empirical research is to test whether U.K. stock market returns, over the 1965-1993, revert (overreaction hypothesis) or the benchmark models are misspecified. In this empirical study there are four theoretical

Table 7.8.
Differences in ACAR Between the Loser and Winner Portfolios
Using the Size-Adjusted CAPM as the Benchmark.

no. of independent replications and length of portfolio formation period	avg. no. of stocks	ACAR at the end of the formation period: winner portfolio	loser portfolio	Difference in ACAR (T-statistics) {Wilcoxon statistics} Months After Portfolio Formation: 1	12	13	24	25	36	37	48	49	60
3 five-years periods	35	0.8132	-0.7650	-0.0264	-0.0773	-0.0688	-0.0978	-0.1208	-0.2143	-0.1979	-0.1904	-0.1897	-0.2068
				(-0.6013)	(-0.8801)	(-0.7466)	(-0.8589)	(-1.0477)	(-1.2077)	(-1.0704)	(-0.8732)	(-0.8644)	(-0.8854)
				{-2}	{-4}	{-4}	{-4}	{-4}	{-4}	{-2}	{-2}	{-2}	{-2}
3 five-year periods (decile)	19	1.0047	-0.9687	-0.0256	-0.1164	-0.1065	-0.1187	-0.1595	-0.2787	-0.2577	-0.2141	-0.2216	-0.2274
				(-0.3891)	(-0.9053)	(-0.8072)	(-0.7509)	(-0.9908)	(-1.0793)	(-0.9866)	(-0.7220)	(-0.7418)	(-0.7580)
				{0}	{-4}	{-4}	{-2}	{-4}	{-4}	{-2}	{-2}	{-2}	{-2}
4 four-year periods	35	0.8298	-0.7402	0.0435	0.0173	-0.0173	0.0056	0.0295	0.1045	0.0880	-0.0397	n.a.	n.a.
				(3.5488)	(0.5226)	(-0.4264)	(0.0906)	(0.5152)	(0.8838)	(0.7110)	(-0.2196)	n.a.	n.a.
				{10}	{2}	{-2}	{0}	{2}	{4}	{2}	{-2}	n.a.	n.a.
4 four-year periods (decile)	23	0.9689	-0.8870	0.0541	0.0275	0.0194	0.0185	0.0585	0.0685	0.0387	-0.0846	n.a.	n.a.
				(4.0944)	(0.6763)	(0.5802)	(0.6947)	(2.2910)	(0.8170)	(0.4293)	(-0.5763)	n.a.	n.a.
				{10}	{6}	{4}	{4}	{8}	{4}	{2}	{-4}	n.a.	n.a.
5 three-year periods	35	0.7476	-0.6702	0.0407	-0.0214	-0.0077	-0.0204	-0.0384	-0.0612	n.a.	n.a.	n.a.	n.a.
				(2.5659)	(-0.8205)	(-0.2302)	(-0.2875)	(-0.6052)	(-0.6194)	n.a.	n.a.	n.a.	n.a.
				{15}	{-5}	{-1}	{-3}	{-3}	{-5}	n.a.	n.a.	n.a.	n.a.
5 three-year periods (decile)	25	0.8499	-0.7757	0.0418	-0.0217	-0.0123	-0.0394	-0.0602	-0.0948	n.a.	n.a.	n.a.	n.a.
				(2.4646)	(-0.7095)	(-0.2802)	(-0.4718)	(-0.7379)	(-0.7452)	n.a.	n.a.	n.a.	n.a.
				{13}	{-3}	{1}	{-3}	{-3}	{-5}	n.a.	n.a.	n.a.	n.a.
8 two-year periods	35	0.6613	-0.5948	0.0277	-0.0351	-0.0230	0.0169	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				(2.7072)	(-1.1372)	(-1.0106)	(0.5042)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				{28}	{-20}	{-18}	{6}	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
8 two-year periods (decile)	28	0.7206	-0.6495	0.0299	-0.0464	-0.0413	0.0142	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				(2.2558)	(-1.2728)	(-1.4119)	(0.3625)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
				{28}	{-18}	{-18}	{4}	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

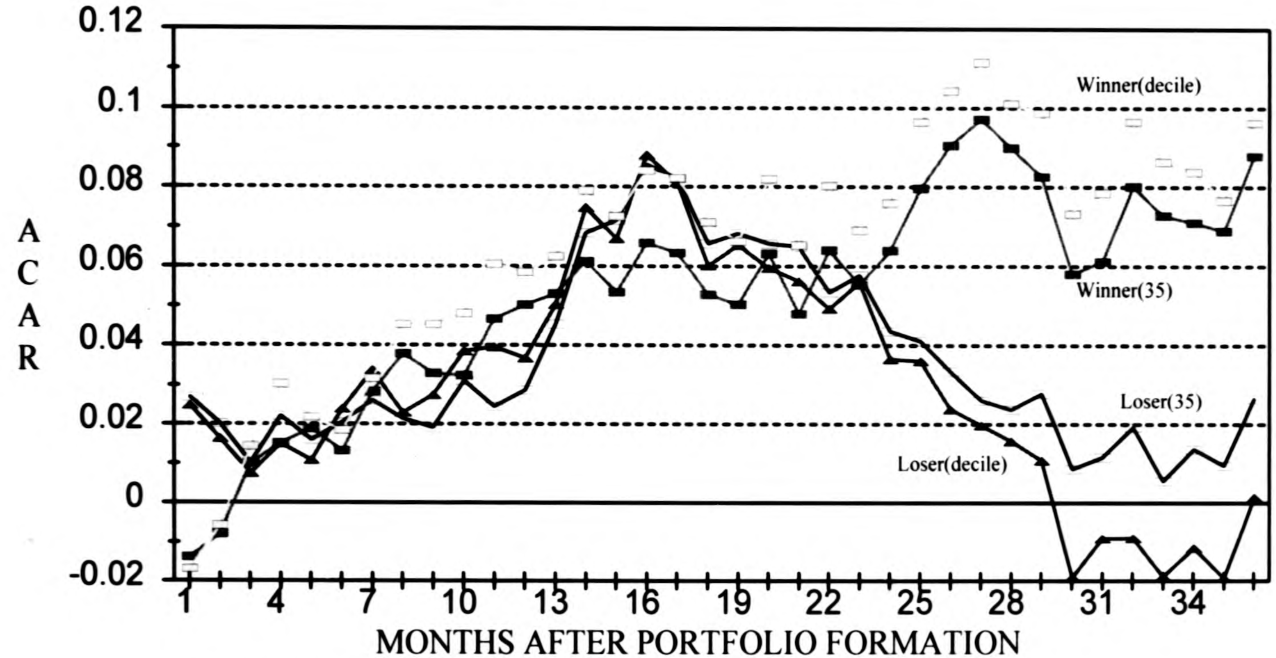
Note:-"a", "b", and "c" represent statistical significance at the 0.10, 0.05, and 0.01 percent levels, respectively.

Figure 7.13. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 8 Two-Year Periods Between January 1972 and December 1987 Using the Size-Adjusted CAPM as the Benchmark Average.



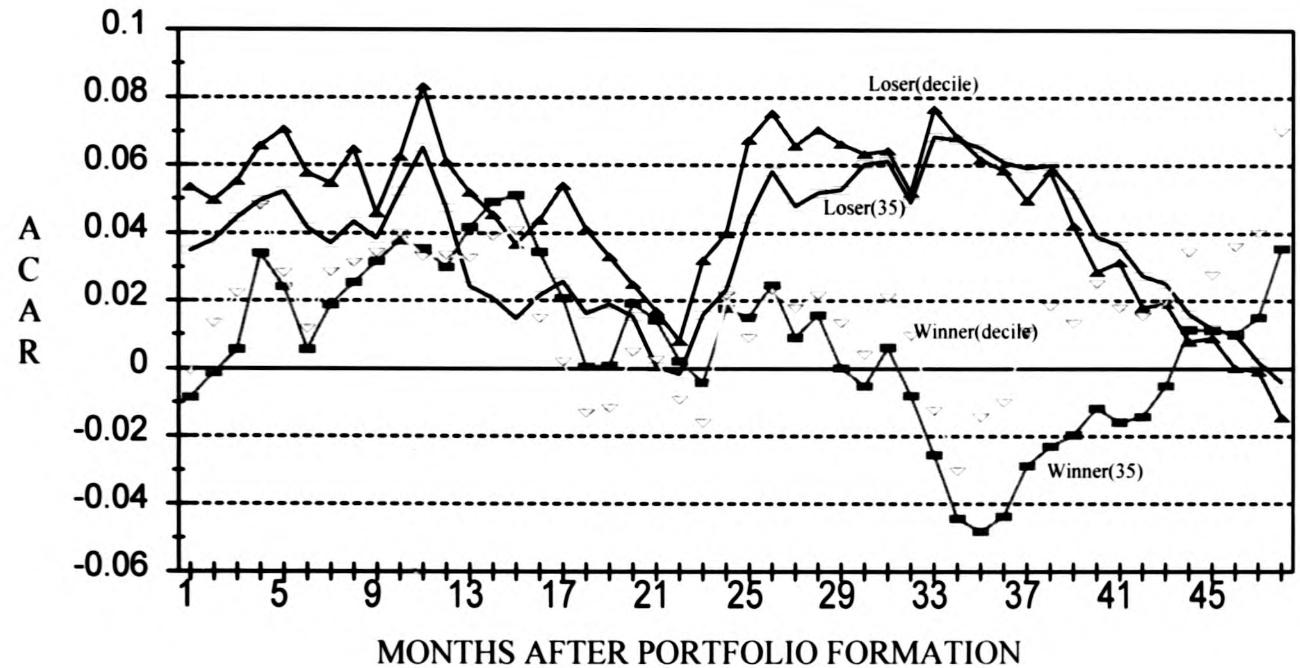
Note:- Loser(35) represents loser portfolio of 35 stocks,
Winner(35) represents winner portfolio of 35 stocks,
Loser(decile) represents loser portfolio of decile,
Winner(decile) represents winner portfolio of decile.

Figure 7.14. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 5 Three-Year Periods Between January 1973 and December 1987 Using the Size-Adjusted CAPM as the Benchmark Average.



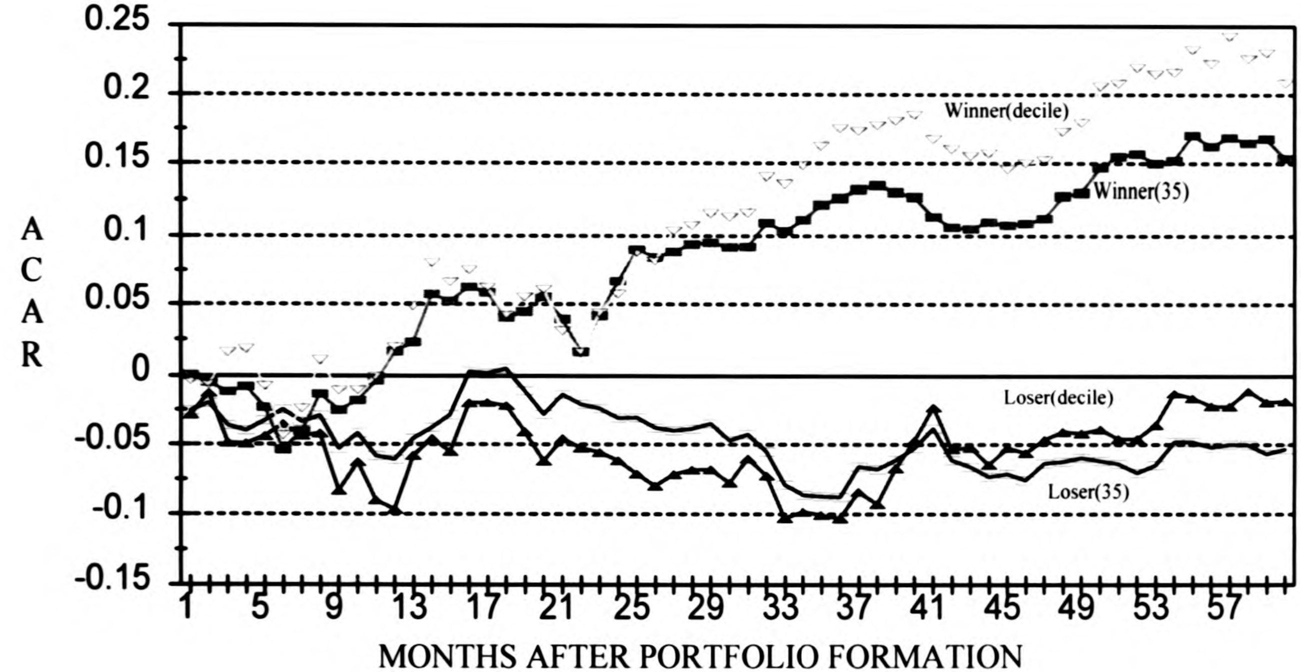
Note:- Loser(35) represents loser portfolio of 35 stocks,
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

Figure 7.15. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 4 Four-Year Periods Between January 1974 and December 1989 Using the Size-Adjusted CAPM as the Benchmark Average.



Note:- Loser(35) represents loser portfolio of 35 stocks.
Winner(35) represents winner portfolio of 35 stocks.
Loser(decile) represents loser portfolio of decile.
Winner(decile) represents winner portfolio of decile.

Figure 7.16. The Behaviour of ACAR for Winners and Losers of 35 Stocks and of Decile for 3 Five-Year Periods Between January 1975 and December 1989Using the Size-Adjusted CAPM as the Benchmark Average.



Note:- Loser(35) represents loser portfolio of 35 stocks,
Winner(35) represents winner portfolio of 35 stocks,
Loser(decile) represents loser portfolio of decile,
Winner(decile) represents winner portfolio of decile.

Table 7.9 The Behaviour of ACAR's for Losers, Winners, and Loser-Minus-Winner of 35 Stocks over Three Nonoverlapping Five-Year Portfolio Test Periods Between January 1875 to December 1989, Based on the Size-Adjusted CAPM Benchmark

Months	Losers (T-Statistics)	Winners (T-Statistics)	L-W (T-Statistics)
1	-0.0257	0.0006	-0.0264
	(-0.5937)	(0.0950)	(-0.6013)
2	-0.0199	-0.0046	-0.0153
	(-0.4952)	(-0.4414)	(-0.3676)
3	-0.0363	-0.0115	-0.0248
	(-0.7586)	(-0.9006)	(-0.5002)
4	-0.0402	-0.0078	-0.0324
	(-0.7157)	(-0.6916)	(-0.5661)
5	-0.0329	-0.0233	-0.0095
	(-0.6927)	(-3.0904)	(-0.1984)
6	-0.0249	-0.0537	0.0288
	(-0.4908)	(-2.4266)	(0.5196)
7	-0.0338	-0.0408	0.0070
	(-0.5017)	(-1.1642)	(0.0927)
8	-0.0293	-0.0134	-0.0159
	(-0.4229)	(-0.5920)	(-0.2177)
9	-0.0530	-0.0254	-0.0276
	(-0.7243)	(-1.2360)	(-0.3634)
10	-0.0420	-0.0182	-0.0238
	(-0.5299)	(-0.8824)	(-0.2904)
11	-0.0581	-0.0033	-0.0548
	(-0.7322)	(-0.1178)	(-0.6513)
12	-0.0606	0.0166	-0.0773
	(-0.7515)	(0.4804)	(-0.8801)
13	-0.0458	0.0230	-0.0688
	(-0.5685)	(0.5147)	(-0.7466)
14	-0.0379	0.0570	-0.0949
	(-0.4574)	(1.1247)	(-0.9768)
15	-0.0288	0.0518	-0.0805
	(-0.3226)	(1.0202)	(-0.7849)
16	0.0030	0.0623	-0.0593
	(0.0320)	(1.3113)	(-0.5642)
17	0.0018	0.0582	-0.0563
	(0.0177)	(0.9814)	(-0.4727)
18	0.0051	0.0404	-0.0353
	(0.0524)	(0.6700)	(-0.3080)

Table 7.9 -- Continued

19	-0.0109	0.0446	-0.0554
	(-0.1096)	(0.6640)	(-0.4630)
20	-0.0285	0.0552	-0.0837
	(-0.2850)	(0.7894)	(-0.6864)
21	-0.0136	0.0393	-0.0529
	(-0.1538)	(0.6370)	(-0.4912)
22	-0.0211	0.0163	-0.0374
	(-0.2521)	(0.2553)	(-0.3554)
23	-0.0242	0.0417	-0.0659
	(-0.2707)	(0.6371)	(-0.5945)
24	-0.0309	0.0668	-0.0978
	(-0.3364)	(0.9958)	(-0.8589)
25	-0.0308	0.0900	-0.1208
	(-0.3397)	(1.2632)	(-1.0477)
26	-0.0381	0.0843	-0.1224
	(-0.4223)	(1.2884)	(-1.0981)
27	-0.0403	0.0885	-0.1288
	(-0.4035)	(1.2710)	(-1.0576)
28	-0.0389	0.0938	-0.1327
	(-0.3747)	(1.2889)	(-1.0462)
29	-0.0350	0.0951	-0.1301
	(-0.3448)	(1.2908)	(-1.0378)
30	-0.0470	0.0919	-0.1389
	(-0.4256)	(1.0717)	(-0.9932)
31	-0.0428	0.0921	-0.1349
	(-0.3717)	(0.9756)	(-0.9057)
32	-0.0551	0.1097	-0.1648
	(-0.4861)	(1.1656)	(-1.1186)
33	-0.0789	0.1036	-0.1825
	(-0.6608)	(1.1802)	(-1.2314)
34	-0.0862	0.1119	-0.1981
	(-0.6888)	(1.1851)	(-1.2636)
35	-0.0873	0.1224	-0.2097
	(-0.6429)	(1.2945)	(-1.2671)
36	-0.0877	0.1266	-0.2143
	(-0.6026)	(1.2473)	(-1.2077)
37	-0.0657	0.1322	-0.1979
	(-0.4521)	(1.1563)	(-1.0704)
38	-0.0678	0.1350	-0.2028
	(-0.4746)	(1.3116)	(-1.1519)
39	-0.0613	0.1305	-0.1919
	(-0.4169)	(1.1860)	(-1.0443)

Table 7 9 -- Continued

40	-0 0525	0 1274	-0 1799
	(-0 3463)	(1 2037)	(-0 9729)
41	-0 0387	0 1141	-0 1528
	(-0 2591)	(1 0054)	(-0 8146)
42	-0 0612	0 1064	-0 1676
	(-0 3911)	(1 0116)	(-0 8891)
43	-0 0660	0 1054	-0 1714
	(-0 4107)	(0 9790)	(-0 8863)
44	-0 0732	0 1103	-0 1835
	(-0 4665)	(0 9973)	(-0 9558)
45	-0 0711	0 1080	-0 1791
	(-0 4431)	(0 9594)	(-0 9137)
46	-0 0759	0 1092	-0 1850
	(-0 4661)	(0 9290)	(-0 9217)
47	-0 0635	0 1128	-0 1763
	(-0 3661)	(0 9282)	(-0 8325)
48	-0 0622	0 1281	-0 1904
	(-0 3542)	(0 9931)	(-0 8732)
49	-0 0595	0 1302	-0 1897
	(-0 3360)	(1 0039)	(-0 8644)
50	-0 0616	0 1470	-0 2086
	(-0 3352)	(1 0830)	(-0 9131)
51	-0 0638	0 1549	-0 2187
	(-0 3405)	(1 1550)	(-0 9494)
52	-0 0703	0 1568	-0 2271
	(-0 3589)	(1 1247)	(-0 9444)
53	-0 0647	0 1499	-0 2146
	(-0 3378)	(1 1030)	(-0 9136)
54	-0 0482	0 1521	-0 2004
	(-0 2589)	(1 0676)	(-0 8543)
55	-0 0482	0 1703	-0 2185
	(-0 2597)	(1 1372)	(-0 9160)
56	-0 0520	0 1622	-0 2142
	(-0 2742)	(1 0363)	(-0 8711)
57	-0 0500	0 1687	-0 2187
	(-0 2672)	(1 1094)	(-0 9074)
58	-0 0502	0 1647	-0 2149
	(-0 2690)	(1 0799)	(-0 8913)
59	-0 0566	0 1678	-0 2244
	(-0 3115)	(1 1113)	(-0 9498)
60	-0 0533	0 1535	-0 2068
	(-0 2863)	(1 0874)	(-0 8854)

models (the naive market return, the market model, the CAPM, and the size-adjusted model) which were employed to measure stock abnormal return performance. After adjusting monthly return data for thin trading and allowing parameters to change smoothly through time as well as the error term to be heteroskedastic, the findings are not robust for the various benchmarks used.

For the results of using market-adjusted excess returns, there is no reversal behaviour for the winners and the losers until the second year of the test period. For the results of using market model residuals, the losers become winners and the winners become losers over the test period. Although the findings are supportive of the overreaction hypothesis, there are two procedures, the parameters' updating and the portfolios grouping procedures, that might cause measurement error in favour of the overreaction hypothesis when the market model is used as benchmark. Therefore, the CAPM seems to be more adequate to the research design. Not surprisingly, the findings no longer agree with the predictions of the overreaction hypothesis. Both winners and losers ACARs behave insignificantly from zero over the test periods for the two, three, and four-year experiments, and they even exhibit continuation behaviour for the five-year experiment. Furthermore, after extracting the firm size factor from the CAPM-adjusted performance, the behaviour patterns, over the test periods, of the ACARs using the size-adjusted residuals of the two extreme portfolios are similar, but closer to each other (the difference in cumulative average residual between the extreme portfolios is smaller, comparing Table 7.6. and Table 7.8.) with those using the CAPM residuals. This result of considering the firm size effect is consistent with that concluded by Ball, Kothari, and Shanken (1995): "The book-to-market and size effects reexamined recently by Fama and French (1992), and the spread effect explored by Amihud and Mendelson (1986), if considered, would only serve to increase the expected return and thus reduce the measured abnormal returns "

The empirical evidence above on the reversal behaviour of U K stock prices is inconclusive Considering the empirical result for the predictive ability of various models in Chapter 5, we may find the relevancy Table 7 10 provides a comparison of the forecast accuracy of the return predictions for the four models

Table 7 10 The Forecast Accuracy of the Return Predictions for market-adjusted model, market model, CAPM, and Size adjusted model

Beta Estimates	All Firms ME	All Firms MSE	All Firms adjusted r_a^2
$\beta = 1$	0 0002	0 0088	0 2354 (1 6263)^a
β_{SMM}	0 0001	0 0084	0 2318 (1 5953)^a
β_{SCAPM}	0 0001	0 0086	0 2392 (1 6561)^b
$\beta_{SIZE\,\&\,BETA}$	0 0001	0 0077	0 3016 (2 0942)^c

Note - 1 t-statistics appear in parentheses
2 "a", "b", and "c" represent statistical significance at the 0 10, 0 05, and 0 02 percent levels, respectively

The adjusted r_a^2 of the CAPM (0 2392) is slightly higher than those of the market and the market-adjusted models, and their forecasting accuracy is close to each other (MSEs are 0 0086 0 0084, and 0 0088 for CAPM, market model, and market-adjusted model, respectively) Looking further down this table, the size-adjusted model possesses even better forecast accuracy (lower MSE, 0 0077) and higher adjusted r_a^2 (0 3016) than the others Then, carefully relating the findings cf the empirical study in this chapter to those of the previous research in Chapter 5, which focuses on the predictive ability of the models and assumes the predictive ability of these models to be robust over time, we may infer that a model that possesses higher predictive ability and produces less statistical measurement error has less power to accept the overreaction hypothesis. In other words, the evidence implies that we cannot reject the hypothesis of U.K. stock market efficiency with respect to the Contrarian Investment Strategy. Further improvements would still be worthwhile. Moreover, the findings reported herein, of no support for the overreaction, are affected by the examination of a more current (and shorter) time period, 1965-1993, while the overreaction studies of U.S. stock markets examine over longer periods, usually, back to 1926 in which World War II is included.

CHAPTER 8

SUMMARY AND CONCLUSIONS

This thesis consists of three major parts The first part documented in Chapter 2 is the general literature review of some financial topics which are indirectly relevant to the other two empirical parts (the detailed literature review related to the two empirical issues will be provided in each pertinent chapter) The two empirical issues concerning the U K stock market price behaviour are (i) the ability of five models in predicting the U K stock market price behaviour, which was examined in Chapters 3, 4, and 5, and (ii) the U K stock market long-term overreaction study which was investigated in Chapters 6 and 7

The literature review chapter was classified into three parts according to the major research directions of the financial literature relevant to my empirical work The first part introduces the development of three risk-adjusted models -- the market model, the Capital Asset Pricing Model (CAPM), and the Arbitrage Pricing Theory (APT) -- in the capital market With the existing empirical evidence relating to the validity of each model, we may gain more insights into the functioning of security markets and the pricing of individual assets The second part of Chapter 2 starts with some theoretical background on the efficient market hypothesis, followed by three issues of the efficient markets hypothesis based on the different types of information involved Finally, the third part of Chapter 2 reports the empirical evidence regarding some major irregularities -- firm-size effect, January effect, Monthly effect, weekend effect, holiday effect, intraday effect, and excess volatility, etc Although some explanations have been offered for each anomaly, there must be a number of interrelated hypotheses on the factors affecting stock returns, and they may not be robust to different sample data

Chapter 3 developed an asset pricing model, called the Leveraged Asset Pricing Theory, which unifies the Arbitrage Pricing Theory and the Modigliani and Miller Theory of capital structure In general, stock prices behave consistently with earnings movements and a decline (increase) in stock prices, meaning that a decline (increase) in market capitalisation, would imply to an increase (decline) in debt/equity ratio (leverage) and volatility of stock returns The model is constructed by relating returns on unlevered assets, obtained from a multi-factor Arbitrage Pricing model, to an unlevered systematic risk measure Then, substituting the equilibrium equation into the modified MM proposition II, the relationship between the common shareholder's rate of return and the leverage factor is obtained One advantage of the LAPT is that it allows the changes in the underlying leverage variable of each company at time t-1 to have immediate impact on its beta estimated at time t The structure of the LAPT makes explicit the leverage factor which is implicit in the conventional models, this means that the effect of the time-varying character of leverage on returns can be incorporated more accurately in the model

One empirical comparative study between five models -- the naive market return, the market model, the CAPM, the APT, and the LAPT, which have different beta estimates -- was carried out in Chapter 4 in order to evaluate the predictive ability of the newly-derived LAPT The Trade-to-Trade and the Discounted Weighted

Estimation methods were used to avoid the problems of the nontrading effect and variation in parameters, respectively Also, the sample data and the empirical methodology used in this study of forecasting performance of the five models were described

The empirical results comparing the predictive ability of the five models were reported in Chapter 5 As expected, the betas estimated by the combined filtering and smoothing estimation method are more stable through time than those estimated simply by the filtering estimation method Therefore, they have mean square errors (MSE) smaller than those of the filtering ones Within the same estimation method, the CAPM betas display higher mean value (close to one), $E(\beta_{FCAPM})$ is 0 9842 and $E(\beta_{SCAPM})$ is 0 9672, and less variability, $SD(\beta_{FCAPM})$ over time is 0 1798 and $SD(\beta_{SCAPM})$ over time is 0 0271 As to the relationships between the different beta estimates, the results seem to imply that any two beta estimates with closer magnitude of variability over time and estimated by same estimation method tend to have higher correlation

Using all stocks that were continuously listed during the ten-year period, Jan 1979 ~ Dec 1988, the adjusted r_{ii}^2 's of the APT and the LAPT were higher than those of the other three models (the naive market return, the market model, and the CAPM) Further, with respect to the two parameter adjustments, the combined filtering and smoothing estimation method outperforms the filtering one with increased predictive power for the market model and the CAPM

For the study investigating the robustness of the predictive ability of the APT and the LAPT over nine different lengths of time period, starting on January 1979, the results seemed to indicate that when the year 1987 was added to the test, the predictive ability of both the APT and the LAPT become higher and the LAPT, which makes explicit the leverage factor in its structure, performed better than the APT in market valuations around that period as more common factors were extracted for the LAPT. The October 1987 market crash appears to have affected these results which seem to indicate that the rapid and significant changes in October 1987 could at least partly be explained by some economic factors (e.g. leverage) rather than just psychological influences on stock market pricing.

At the end of Chapter 5, suggestions have been offered for further research in improving the LAPT: (a) The book value of debt will not be a suitable proxy for the market value of debt during the periods that interest rates are extremely volatile. (b) It should be noted that long-term liability reported by Datastream includes loans from group companies and associates, so loans of a company from its group companies and associates will be cancelled out and may not affect the company's risk. (c) In the tests debt was measured as the book value of long-term reported liabilities obtained from the Datastream company balance sheet data and was updated at the accounting year-ends. Thus, the monthly debt levels were not reported. This may have produced estimation bias.

Based on the controversial work of De Bondt and Thaler (1985), Chapters 6 and 7 examined the long-term overreaction behaviour in U.K. stock returns. According to the literature, several reasons, i e psychological factors, changing risks of winners and losers, misspecification of the equilibrium pricing model. January effect, return volatility effect, positive feedback trading, and stock market inefficiency, etc , have been offered to explain this systematic residual behaviour -- overreaction Employing the same estimation procedures and the data used in Chapters 4 and 5, Chapter 6 reports a brief empirical study of U K stock market long-term overreaction behaviour At the first sight, the results of the preliminary data analysis seemed to support the market overreaction hypothesis that stocks with the lowest returns (losers) over the portfolio formation period 1980-1982 subsequently outperformed the stocks with the highest returns (winners) over the test period 1983-1985, but market capitalisation effects obscured this conclusion Therefore, firm size effects were considered in the design of this empirical research methodology Also, data sources and the procedures for construction of the extreme portfolios and tests for the overreaction study were specified in this chapter

The empirical results of testing the U K stock market long-term overreaction hypothesis were reported in Chapter 7 After adjusting monthly return data for thin trading, allowing parameters to change smoothly through time, and the errors term to be heteroskedastic, the findings are not robust for the various benchmarks used For the results of using market-adjusted excess returns, there is no reversal behaviour for the winners and the losers until the second year of the test period For the results of using market model residuals, the losers become winners and the winners become losers over the test period Although the findings are supportive of the overreaction hypothesis, there are two procedures, the parameters' updating and the portfolios grouping procedures, that might cause measurement error in favour of the overreaction hypothesis when the market model is used as benchmark. Therefore, the CAPM seems to be more adequate to the research design. Not surprisingly, the findings no longer agree with the predictions of the overreaction hypothesis. Both winners and losers ACARs behave insignificantly from zero over the test periods for the two, three, and four-year experiment and they even exhibit continuation behaviour for the five-year experiment. Furthermore, after extracting the firm size factor from the CAPM-adjusted performance, the behaviour patterns of the ACARs, using the size-adjusted residuals, of the two extreme portfolios are similar, but closer to each other, than those using the CAPM residuals.

The empirical evidence on the reversal behaviour of U.K. stock prices is inconclusive. One thing we learned from this study is that the choice of a model used as benchmark and the design of methodology have to be considered together, because some combination of these may produce bias manifested in apparent but spurious mean reverting behaviour. After carefully relating the findings of this empirical study to those of the previous research in Chapter 5, which focuses on the predictive ability of models, and assumes the predictive ability of these models is robust over time, we may infer that a model that possesses higher predictive ability and produces less statistical measurement error has less power to accept the overreaction hypothesis. In other words, the evidence implies that we cannot reject the hypothesis of U.K. stock market efficiency with respect to the Contrarian Investment Strategy.

We know that social science is not a precise science, it is the scientific study of society As Fama (1991) stated, in his view, that "the market efficiency literature should be judged on how it improves our ability to describe the time-series and cross-section behaviour of security returns " This thesis was not an attempt to explain all apparent stock market anomalies, it focused on the predictive ability of the asset pricing models, and the relationship between any U K stock market long-term overreaction behaviour and the predictive ability of the benchmarks used The results from this study seem to show that the U K stock market has been inefficient only if the market model is used as the benchmark However, further research would still be worthwhile to do For instance, the findings reported in this thesis might be affected by the examination of a more current (and shorter) time period, or by longer periods extending back as far as relevant and reliable data can be found

APPENDIX A

Discount Weighted Estimation (DWE)

(I) Derivation of the DWE

The Multiple Regression Dynamic Linear model is defined by

Observation equation $Y_t = F_t'\beta_t + v_t, \quad v_t \sim N[0, V_t],$

System equation $\beta_t = \beta_{t-1} + \omega_t, \quad \omega_t \sim N[0, W_t]$

where Y_t is the dependent variable at time t,

F_t' is the kx1 vector of independent variables at time t,

β_t is the kx1 vector of regression parameter at time t,

v_t is the observational error or noise term distributed with zero mean and variance V_t,

ω_t is the kx1 vector of evolution error for β_t with zero mean and evolution variance matrix W_t at time t,

and the error sequences v_t and ω_t are assumed to be independent sequences with, in addition, v_t independent of ω_s, for all time t and s.

Suppose that we believe V to be subject to some random disturbance which moves up and down over the time interval t-1 to t, but without showing a tendency towards a steady upward or downward movement. The simplest specification of modelling steady, stochastic variation is via a process which is called random walk, or first-order polynomial model for V or some function of V. We use such a model here for the reciprocal variance, or precision, $\phi = V^{-1}$ rather than V directly since the discussion can sometimes appear clearer in terms of the precision.

Now, let the natural posterior distribution for the observation precision given the information set at time t-1, D_{t-1}, be

(i) $$(\phi_{t-1}|D_{t-1}) \sim \Gamma\left[\tfrac{n_{t-1}}{2}, \tfrac{S_{t-1}}{2}\right]$$

where $\Gamma[\ ]$ represents the gamma distribution with the degree of freedom n_{t-1},

$$E[\phi_{t-1}|D_{t-1}] = \frac{n_{t-1}/2}{S_{t-1}/2} = \frac{n_{t-1}}{S_{t-1}} = \frac{1}{V_{t-1}},$$

and $$Var(\phi_{t-1}|D_{t-1}) = \frac{n_{t-1}/2}{\left(S_{t-1}/2\right)^2} = \frac{2}{n_{t-1}\left(V_{t-1}\right)^2}$$

A random walk over the time interval gives the precision at time t as $\phi_t = \phi_{t-1} + \varphi_t$. In other words, the precision in the current period is equal to the precision in the previous period plus a random disturbance Where the random disturbance φ_t is uncorrelated with $(\phi_{t-1}|D_{t-1})$

Let the notation $\varphi_t \sim [0, \Psi_t]$, be an unspecified distribution for φ_t with mean zero and variance Ψ_t, and such that the prior distribution $(\phi_t|D_{t-1})$ is approximately gamma distributed

Thus, evolving to time t through the random walk, $\phi_t = \phi_{t-1} + \varphi_t$, we find that the mean $E[\phi_t|D_{t-1}] = E[\phi_{t-1} + \varphi_t|D_{t-1}] = 1/V_{t-1}$ is unchanged, but the variance increases as $Var[\phi_t|D_{t-1}] = Var[\phi_{t-1}|D_{t-1}] + Var[\varphi_t|D_{t-1}] = \dfrac{2}{(n_{t-1}V_{t-1}^{\,2})} + \Psi_t$

The variance Ψ_t controls the magnitude of changes, and it is practically useful to think of variance increases $(0 < \delta_v \le 1)$ in a multiplicitive rather than additive sense, thus assume

$Var[\phi_t|D_{t-1}] = \dfrac{2}{(\delta_v n_{t-1}V_{t-1}^{\,2})}$, where δ_v is a discount factor which may be used to choose appropriate value of Ψ_t. Thus prior gamma distribution must be consistent with the mean and variance mentioned above It is easily verified that the unique gamma distribution with these moments is defined as

(ii) $$(\phi_t|D_{t-1}) \sim \Gamma\left(\frac{\delta_v n_{t-1}}{2}, \frac{\delta_v S_{t-1}}{2}\right)$$

$$\ln f(\phi_t|D_{t-1}) = \left(\frac{\delta_v n_{t-1}}{2} - 1\right)\ln \phi_t - \frac{\delta_v S_{t-1}\phi_t}{2} + \text{constant}$$

for each time $t \ge 1$, conditional on V_t, the following one-step forecast and posterior distributions are derived by the additivity, linearity and distributional closure properties of the normal linear structure

(iii) Let us suppose the posterior distribution for β_{t-1} is

$$(\beta_{t-1}|D_{t-1}, \phi_{t-1}) \sim N[m_{t-1}, C_{t-1}\phi_{t-1}^{-1}]$$

for some mean m_{t-1} and variance C_{t-1};

(iv) Then conditional on D_{t-1} and ϕ_t, β_t is the sum of two independent normal random quantities β_{t-1} and ω_t, so is itself normal And by the definition of Discount Weighted Estimates (D W E), the prior distribution for β_t is

$$(\beta_t|D_{t-1}, \phi_t) \sim N[m_{t-1}, R_t\phi_t^{-1}]$$

$$\begin{aligned}
\text{where } E[\beta_t|D_{t-1},\phi_t] &= E[\beta_{t-1}+\omega_t|D_{t-1},\phi_t] \\
&= E[\beta_{t-1}|D_{t-1},\phi_t]+E[\omega_t|D_{t-1},\phi_t] \\
&= m_{t-1}, \\
Var[\beta_t|D_{t-1},\phi_t] &= Var[\beta_{t-1}+\omega_t|D_{t-1},\phi_t] \\
&= (C_{t-1}+W_t)\phi_t^{-1} = \Delta C_{t-1}\phi_t^{-1}\Delta, \\
\text{and } \quad R_t = C_{t-1}+W_t &= \Delta C_{t-1}\Delta, \\
\Delta &= diag\left(1\Big/\sqrt{\delta_1}, 1\Big/\sqrt{\delta_2}, \ldots\ldots, 1\Big/\sqrt{\delta_k} \right)
\end{aligned}$$

And the natural logarithmic scale provides $f(\beta_t|D_{t-1},\phi_t)$, a multivariate normal distribution in k dimensions, a simpler additive expression

$$\ln f(\beta_t|D_{t-1},\phi_t) = \frac{1}{2}\left[k\ln\phi_t - (\beta_t - m_{t-1})'\left(R_t\phi_t^{-1}\right)^{-1}(\beta_t - m_{t-1})\right] + \text{const}$$

There , the use of discount factors δ_k , $(0<\delta_k\le 1)$, k=1,....,k, linked W_t to C_{t-1} via $W_t = \Delta C_{t-1}\Delta\left(I-\Delta^{-1}\Delta^{-1}\right)$ Thus W_t has precisely the same internal structure as C_{t-1} , and the magnitude of C_{t-1} is controlled by the discount factors.

This implies increases in variances, or loss of information , of $100\Delta\Delta\left(I-\Delta^{-1}\Delta^{-1}\right)\%$, and leads to thinking in terms of a natural rate of decay of information that suggests a multiplicative, instead of additive, increase in uncertainty.

Similarly, and again conditional upon D_{t-1} and ϕ_t , Y_t is the sum of the independent normal quantities $F_t\beta_t$ and v_t and so the one-step forecast distribution is normal

(v) $\qquad (Y_t|D_{t-1},\phi_t) \sim N\left[F_t' m_{t-1}, q\phi_t^{-1}\right]$

$$\begin{aligned}
\text{where } E[Y_t|D_{t-1},\phi_t] &= E\left[F_t'\beta_t + v_t|D_{t-1},\phi_t\right] \\
&= E\left[F_t'\beta_t|D_{t-1},\phi_t\right] + E[v_t|D_{t-1},\phi_t] \\
&= F_t' m_{t-1}
\end{aligned}$$

$$\begin{aligned}
Var[Y_t|D_{t-1},\phi_t] &= Var\left[F_t'\beta_t + v_t|D_{t-1},\phi_t\right] \\
&= Var\left[F_t'\beta_t|D_{t-1},\phi_t\right] + Var[v_t|D_{t-1},\phi_t] \\
&= F_t' R_t\phi_t^{-1}F_t + \phi_t^{-1} \\
&= q_t\phi_t^{-1}, \qquad q_t = F_t' R_t F_t + 1 .
\end{aligned}$$

$$\ln f(Y_t|D_{t-1},\phi_t) = \frac{1}{2}\left[\ln\phi_t - \left(Y_t - F_t' m_{t-1}\right) q_t^{-1}\phi_t\left(Y_t - F_t' m_{t-1}\right)\right] + \text{const}$$

(vi) We know that any linear function of Y_t and β_t will be a linear combination of the independent normal quantities ν_t , ω_t , and β_{t-1} And so $(Y_t,\beta_t|D_{t-1},\phi_t)$ conditional on D_{t-1} and ϕ_t , will be bivariate normal

From the two distributions (vi) and (v) , it is possible to construct the joint distribution for Y_t and β_t , conditional on D_{t-1} and ϕ_t ,

$$\begin{pmatrix} Y_t \\ \beta_t \end{pmatrix} | D_{t-1},\phi_t \Bigg) \sim N\left[\begin{pmatrix} F_t' m_{t-1} \\ m_{t-1}\end{pmatrix}, \begin{pmatrix} q_t\phi_t^{-1} & F_t' R_t\phi_t^{-1} \\ R_t F_t\phi_t^{-1} & R_t\phi_t^{-1}\end{pmatrix}\right]$$

where the covariance is simply

$$\begin{aligned} COV[Y_t,\beta_t|D_{t-1},\phi_t] &= COV\left[F_t'\beta_t + \nu_t,\beta_t|D_{t-1},\phi_t\right] \\ &= COV\left[F_t'\beta_t,\beta_t|D_{t-1},\phi_t\right] + COV[\nu_t,\beta_t|D_{t-1},\phi_t] \\ &= F_t' Var[\beta_t|D_{t-1},\phi_t] + 0 \\ &= F_t' R_t\phi_t^{-1} \end{aligned}$$

And hence the particular case of the bivariate normal is directly applicable to obtain the posterior distribution for β_t , conditional on Y_t , ϕ_t ;

$$(\beta_t|y_t,D_{t-1},\phi_t) \sim N\left[m_t,C_t\phi_t^{-1}\right]$$

with m_t and C_t independent of ϕ_t , where

$$\begin{aligned} m_t &= m_{t-1} + \frac{F_t' R_t\phi_t^{-1}}{q_t\phi_t^{-1}}\left(Y_t - F_t' m_{t-1}\right) \\ &= m_{t-1} + A_t e_t \end{aligned}$$

and $$C_t\phi_t^{-1} = R_t\phi_t^{-1} - \frac{R_t F_t\phi_t^{-2} F_t' R_t}{q_t\phi_t^{-1}}$$

$$\begin{aligned} &= R_t\phi_t^{-1} - \frac{R_t F_t F_t' R_t\phi_t^{-1}}{q_t} \\ &= R_t\left(I - A_t F_t'\right)\phi_t^{-1} \end{aligned}$$

$$A_t = C_t F_t = {R_t F_t}/{q_t}$$
$$C_t = R_t\left(I - A_t F_t'\right)$$

(vi) Assume that the prior distribution for precision $\phi_t = V_t^{-1}$, $\left(\frac{\delta_v S_{t-1}}{2}, \frac{S_v n_{t-1}}{2}\right)$, holds. So now, the posterior distribution for ϕ_t could be obtained by Bayes' Theorem $f(\phi_t|D_t) \propto f(\phi_t|D_{t-1}) f(Y_t|D_{t-1}, \phi_t)$.

Using the prior distribution for precision ϕ_t from (ii) and the likelihood from (v), the posterior distribution for ϕ_t is

$$\ln f(\phi_t|D_t) \propto \left(\frac{\delta_v n_{t-1}}{2} - 1\right)\ln \phi_t - \frac{\delta_v S_{t-1}\phi_t}{2} + \frac{1}{2}\ln \phi_t - \frac{1}{2}\left(Y_t - F_t' m_{t-1}\right) q_t^{-1}\phi_t\left(Y_t - F_t' m_{t-1}\right)$$

$$\propto \frac{1}{2}\left[(\delta_v n_{t-1} - 1)\ln \phi_t - \left(\delta_v S_{t-1} + q_t^{-1} e_t^2\right)\phi_t\right]$$

So, $$(\phi_t|D_t) \sim \Gamma\left(\frac{n_t}{2}, \frac{S_t}{2}\right),$$

where $n_t = \delta_v n_{t-1} + 1$

and $S_t = \delta_v S_{t-1} + q_t^{-1} e_t^2$

(vii) The sequential updating and forecasting components of the Dynamic Linear Model as above is to infer the state of the time series process and observations at time t-1, t, conditional on the information available at time t-1. In some situation, the information made available after time t is taken into account. This is called smoothing time series. In statistical terminology, the distribution of $(\beta_t|D_{t+s})$, for $s \geq 1$ and any fix time t, is called k-step filtered (smoothed) distribution for the state vector at time t+k; the information recently obtained is filtered back to previous time points. Since the estimate of $(\beta_t|D_{t+s})$ is based on more information than the estimates of $(\beta_t|D_{t-1})$ or $(\beta_t|D_t)$, it will have a mean square error (MSE) which, in general, is smaller than that of the estimate of $(\beta_t|D_{t-1})$ or $(\beta_t|D_t)$; it can not be greater.

The following is the inferences of the s-step filtered distributions of the state vector at any given time t. For $s \geq 1$, the s-step filtered distributions with negative arguments are defined by

$$(\beta_t|D_{t+s}) \sim N\left[a_{t+s}(-s), R_{t+s}(-s)\right],$$

where $\quad a_{t+s}(-s) = \left(1 - \frac{1}{\Delta\Delta}\right)m_t + \frac{1}{\Delta\Delta}a_{t+s}(-s+1),$

and $\quad R_{t+s}(-s) = \left(1 - \frac{1}{\Delta\Delta}\right)C_t\phi_t^{-1} + \frac{1}{\Delta\Delta\Delta\Delta}R_{t+s}(-s+1)$

Proof

From (iii) and (iv), we know that

$$(\beta_t | D_t, \phi_t) \sim N\left[m_t, C_t\phi_t^{-1}\right],$$

and $\quad (\beta_{t+1} | D_t, \phi_t) \sim N\left[m_t, R_{t+1}\phi_t^{-1}\right],$

where $\quad R_{t+1} = C_t + W_{t+1} = \Delta C_t \Delta$

The joint distribution for β_t and β_{t+1}, conditional on D_t and ϕ_t is

$$\left(\begin{matrix}\beta_t \\ \beta_{t+1}\end{matrix} | D_t, \phi_t\right) \sim N\left[\begin{pmatrix} m_t \\ m_t \end{pmatrix}, \begin{pmatrix} C_t\phi_t^{-1} & C_t\phi_t^{-1} \\ C_t\phi_t^{-1} & R_{t+1}\phi_t^{-1} \end{pmatrix}\right],$$

where the covariance is simply

$$\begin{aligned} COV\left[\beta_t, \beta_{t+1} | D_t, \phi_t\right] &= COV\left[\beta_t, \beta_t + \omega_{t+1} | D_t, \phi_t\right] \\ &= Var\left[\beta_t | D_t, \phi_t\right] = C_t\phi_t^{-1} \end{aligned}$$

According to the jointly bivariate normal distribution, the distribution for β_t, conditional on β_{t+1}, D_t and ϕ_t, is still normal with

$$\begin{aligned} E\left[\beta_t | \beta_{t+1}, D_t, \phi_t\right] &= m_t + \frac{C_t\phi_t^{-1}}{R_{t+1}\phi_t^{-1}}(\beta_{t+1} - m_t) \\ &= m_t + \frac{C_t\phi_t^{-1}}{\Delta C_t \Delta \phi_t^{-1}}(\beta_{t+1} - m_t) \\ &= \left(1 - \frac{1}{\Delta\Delta}\right)m_t + \frac{1}{\Delta\Delta}\beta_{t+1}, \end{aligned}$$

and $\quad Var\left[\beta_t | \beta_{t+1}, D_t, \phi_t\right] = C_t\phi_t^{-1} - \frac{C_t\phi_t^{-1}C_t\phi_t^{-1}}{\Delta C_t \Delta \phi_t^{-1}}$

$$= \left(1 - \frac{1}{\Delta\Delta}\right)C_t\phi_t^{-1}$$

Then, returning to the s-step filtered distribution, the required distribution of β_t, given D_{t+s} and ϕ_t is

$$(\beta_t | D_{t+s}) \sim N[a_{t+s}(-s), R_{t+s}(-s)],$$

where $a_{t+s}(-s) = E[\beta_t | D_{t+s}] = E\{E[\beta_t | \beta_{t+1}, D_t, \phi_t] | D_{t+s}\}$

$$= \left(1 - \frac{1}{\Delta\Delta}\right) m_t + \frac{1}{\Delta\Delta} E[\beta_{t+1} | D_{t+s}]$$

$$= \left(1 - \frac{1}{\Delta\Delta}\right) m_t + \frac{1}{\Delta\Delta} a_{t+s}(-s+1).$$

$$R_{t+s}(-s) = Var[\beta_t | D_{t+s}] = E\{Var[\beta_t | \beta_{t+1}, D_t, \phi_t] | D_{t+s}\} + Var\{E[\beta_t | \beta_{t+1}, D_t, \phi_t] | D_{t+s}\}$$

$$= E\left[\left(1 - \frac{1}{\Delta\Delta}\right) C_t \phi_t^{-1} \middle| D_{t+s}\right] + Var\left[\left(1 - \frac{1}{\Delta\Delta}\right) m_t + \frac{1}{\Delta\Delta} \beta_{t+1} \middle| D_{t+s}\right]$$

$$= \left(1 - \frac{1}{\Delta\Delta}\right) C_t \phi_t^{-1} + \frac{1}{\Delta\Delta\Delta\Delta} R_{t+s}(-s+1)$$

(II) An Algorithm for a DWE Programming Study

(i) Update Estimates of Coefficients (β_t)

1. $\Delta = diag\left(1/\sqrt{\delta_1}, 1/\sqrt{\delta_2}, \ldots\ldots, 1/\sqrt{\delta_k} \right)$;
2. C_0 = Maxint * I ;
   $m_0 = 0$;
   $t = 0$;

$R_{t+1} = \Delta C_t \Delta$;
$q_{t+1} = F_{t+1}' R_{t+1} F_{t+1} + 1$;
$A_{t+1} = R_{t+1} F_{t+1} / q_{t+1}$;

$m_{t+1} = m_t + A_{t+1}(Y_{t+1} - F_{t+1}' m_t)$;
$C_{t+1} = R_{t+1}(I - A_{t+1} F_{t+1}')$;
$t = t + 1$;

1 Naturally, $\Delta = diag\left(1\big/\sqrt{\delta_1}, 1\big/\sqrt{\delta_2}, \ldots\ldots, 1\big/\sqrt{\delta_k} \right)$ is a function of the data series and the sampling interval Harrison and Johnston (1984) suggest as a rough guide is to set $\delta = (3 * N - 1)/(3 * N + 1)$ for all δ's, with N=20* k (where k is the number of regression parameters) This formula has been used to obtain the results regarded in this thesis If all δ's were to be set equal to one, then the results at the last time point obtained from the DWE are identical to those obtained from ordinary least squares regression over all data points

2 The initial values of the diagonal elements of the matrix C_0 were set to very large numbers, and the other elements of the matrix were set to zero The initial parameter estimates in vector m_0 were set to zero Usually, in Bayesian estimation, the values of m and C all become realistic after k+1 data points unless some of the independent variables are non-informative (or δ is given an extremely small value) relative to k

(ii) Update Estimate of Residual Variance (V_t)

1. $S_0 = 0$;
$n_0 = 0$;
$t = 0$;

2. $S_{t+1} = \delta_v S_t + q_{t+1}^{-1}\left(Y_{t+1} - F'_{t+1} m_t\right)^2$;
$n_{t+1} = \delta_v n_t + 1$;
$\hat{V}_{t+1} = \dfrac{S_{t+1}}{n_{t+1}}$,
$t = t + 1$,

1 If there is no original information about the estimate during the first k' points, S_k and n_k must be set equal to zero

2 The method of choosing the δ_v is the same as for Δ above

APPENDIX B

The Liabilities, Market values, and adjusted r_a^2's of the 172 Sample Firms

No	Name	Debt (1979)	Debt (1988)	MV (1979)	MV (1988)	APT r_a^2	LAPT r_a^2
1	BROWN (N) GROUP	0	5000	51	915	0.2420	0.3109
2	BRYANT GROUP	2499	200	96	2281	0.3678	0.4542
3	BSG INTL	9683	8967	256	1087	0.3977	0.3980
4	BSS GROUP	1167	0	94	717	0.3238	0.3618
5	BSTL.EVNG.POST	1019	847	46	428	0.2173	0.2504
6	BTP	1449	11630	75	702	0.5019	0.5309
7	BULLOUGH	2025	18120	156	1601	0.4176	0.4771
8	BULMER (HP)	2967	22301	150	710	0.2256	0.2629
9	BUNZL	16949	210500	238	5691	0.4561	0.4581
10	BURMAH CASTROL	282045	176300	1353	8290	0.3067	0.3088
11	BURNDENE INVS	1620	1447	16	168	0.1492	0.2767
12	BURTON GROUP	20161	228600	94	9248	0.3734	0.2610
13	CANNING (W)	4182	8360	59	364	0.4289	0.4286
14	CARCLO ENGR GP	216	9961	29	659	0.1616	0.2766
15	CASTINGS	229	0	39	196	0.0679	0.1276
16	CHARTER	57545	54903	1510	4776	0.3775	0.5469
17	CHLORIDE GROUP	42805	31000	1199	1318	0.2684	0.2398
18	CHRISTIES INTL	0	0	157	2106	0.3745	0.4833
19	CHURCH & CO.	1272	100	85	477	0.0862	0.2424
20	COATS VIYELLA	3483	142900	235	7658	0.3684	0.4772
21	CONCENTRIC	0	0	69	432	0.3494	0.3829
22	COOK (WILLIAM)	50	5504	9	223	0.0056	0.2698
23	COOKSON GROUP	13942	120400	624	4643	0.5343	0.5755
24	COSTAIN GROUP	18895	162400	939	5087	0.5067	0.5330
25	COUNTRYSIDE PR	0	4394	29	947	0.5280	0.6950
26	COURTAULDS	341100	277700	3060	10147	0.4685	0.4643
27	COURTS	1376	6805	20	51	0.1413	0.2965
28	COWIE GROUP	2840	6470	52	1546	0.4352	0.4079
29	CRAY ELTN HDG	1383	1071	39	1164	0.1554	0.2346
30	CREST NICHOLSON	3625	63063	92	1366	0.4901	0.5456
31	CRODA INTL	20180	7800	587	1989	0.3193	0.4038
32	DAILY MAIL&GEN.	1200	0	183	2340	0.4150	0.4393
33	DALGETY	82400	150900	1479	6715	0.5390	0.5102
34	DAWSON INTL	4041	35301	419	3162	0.5226	0.5792
35	DE LA RUE	5798	22600	1332	5753	0.3592	0.3871
36	DEWHIRST GROUP	602	1575	90	321	0.1763	0.2049
37	DIPLOMA	443	400	208	1053	0.4496	0.5698
38	DIXONS GP	6554	258400	465	4950	0.4735	0.5127
39	DOBSON PARK	2275	7434	688	970	0.3579	0.3835
40	DOWDING & MILLS	0	1758	87	542	0.2052	0.2609
41	EIS GROUP	916	2257	65	645	0.2809	0.3362
42	ELECTROCOMPONENTS	0	14100	644	3833	0.3838	0.5457
43	ELLIS & EVERARD	1501	6082	64	572	0.3429	0.4336

Appendix B -- Continued.

No.	Name	Debt (1979)	Debt (1988)	MV (1979)	MV (1988)	APT r_u^2	LAPT r_u^2
44	ENG.CHINA CLAYS	14375	46700	1369	9667	0.6519	0.6691
45	EXPAMET INTL	258	4177	146	542	0.3726	0.3807
46	FARNELL ELTN	0	0	248	1737	0.4567	0.6067
47	FENNER	3141	25388	432	565	0.2630	0.3275
48	FERGUSON INTL	1440	3337	89	768	0.3082	0.2941
49	FINE ART DEV.	526	10480	256	1475	0.4523	0.4489
50	FINLAY (JAMES)	9229	29117	359	1058	0.2211	0.3467
51	FISONS	58278	44600	1124	11353	0.3314	0.3357
52	GENERAL ELEC.	299500	68500	17722	50698	0.3868	0.5748
53	GESTETNER	26411	58000	9	958	0.3496	0.0239
54	GLAXO	44478	12000	4080	79214	0.4518	0.4910
55	GLEESON (MJ)	0	0	33	600	0.2879	0.3951
56	GLYNWED	26049	70400	678	3035	0.5600	0.6308
57	GRAMPIAN HDG	2557	4793	56	1117	0.3823	0.3680
58	GRAND MET.	355586	740100	5129	36866	0.5595	0.6584
59	GREENALLS GP.	29937	124243	646	2939	0.3602	0.3836
60	GREENE, KING	1444	2858	322	1867	0.1464	0.2860
61	GT.UNVL.STORES	42748	19900	170	856	0.3787	0.4053
62	GUINNESS	58600	931000	1422	27630	0.4458	0.4226
63	HALL ENGINEERING	9817	5844	134	567	0.3493	0.4106
64	HALMA	210	1594	47	1137	0.3714	0.4030
65	HALSTEAD (JAMES)	626	200	34	345	0.0640	0.1141
66	HANSON	46900	2271000	1002	55810	0.3655	0.3922
67	HARDYS&HANSONS	625	625	73	320	0.1497	0.3027
68	HARRISONS &CROS.	16471	210400	2704	8513	0.2542	0.3384
69	HELENE	1648	1506	26	130	0.2614	0.3005
70	HENLYS GROUP	16	8758	68	439	0.2254	0.3374
71	HEPWORTH	28005	17256	1007	4367	0.5516	0.5831
72	HEWDEN-STUART	14817	14683	358	1085	0.4294	0.4027
73	HICKING,PENTCST.	390	293	28	49	0.2431	0.3084
74	HICKSON INTL.	3451	29835	390	1614	0.5528	0.6135
75	HIGGS & HILL	3159	1248	46	1065	0.4762	0.4798
76	HIGHLAND DISTL.	0	0	232	1654	0.1434	0.1256
77	HILL & SMITH	1513	1000	42	303	0.2324	0.2877
78	HOLT (JOSEPH)	223	0	75	354	0.0001	0.0876
79	HOPKINSONS GP.	350	14153	106	577	0.3182	0.3381
80	HOWDEN GROUP	3535	15592	166	801	0.4162	0.4337
81	HTV GROUP	1210	0	122	185	0.2753	0.2802
82	HUNTING	1005	5512	19	363	0.2779	0.2860
83	IBSTOCK	9232	25306	158	2399	0.5614	0.5723
84	IMI	42747	113500	1187	5848	0.5747	0.6455
85	IMP.CHM.INDS.	1093000	1652000	20113	67153	0.4877	0.5958
86	JHNSN.&FTH.BROWN	47275	18269	643	689	0.2353	0.2352
87	JOHNSONMATTHEY	36010	49300	330	5695	0.2806	0.3611
88	JONES,STROUD	1318	1093	84	425	0.2671	0.3626

Appendix B -- Continued.

No.	Name	Debt (1979)	Debt (1988)	MV (1979)	MV (1988)	APT r_u^2	LAPT r_u^2
89	KALON GROUP	1175	5997	75	399	0.1557	0.2107
90	KWIK SAVE GP	0	0	538	5666	0.4693	0.5908
91	KWIK-FIT HDG.	1134	9903	74	957	0.1879	0.1790
92	PEN.&ORNTL DFD	301995	893300	1243	20201	0.3401	0.3256
93	PERRY GROUP	2188	8199	101	362	0.3433	0.3769
94	PHOTO-ME INTL	337	1209	77	1176	0.0142	0.0180
95	PIFCO HDG	0	410	23	66	0.0183	0.1332
96	PILKINGTON	101800	421800	3545	14992	0.5795	0.5689
97	PLYSU	750	5000	69	636	0.1893	0.3190
98	PORTS.SUND.NWSP	250	2348	59	291	0.0830	0.1574
99	POWELL DUFFRYN	13693	47783	532	2332	0.3499	0.4035
100	POWERSCREEN	0	2320	36	562	0.0709	0.1550
101	PREMIER CONS.OIL	0	3132	100	2248	0.1572	0.4907
102	RACAL ELECTRONIC	36587	205073	4015	18928	0.2434	0.4478
103	RAINE	0	5429	21	1028	0.2840	0.2978
104	READICUT INTL	3904	8140	323	788	0.3269	0.2862
105	REED INTL	380800	94200	1821	20493	0.6060	0.4950
106	RENOLD	21208	18700	459	513	0.2873	0.2165
107	RENTOKIL GROUP	1709	233	663	4342	0.3504	0.3873
108	RICARDO GP.	60	811	83	167	0.2358	0.2978
109	RMC GROUP	22561	78000	945	9752	0.5315	0.5946
110	ROTORK	1919	295	94	390	0.3392	0.4570
111	RTZ CORP.	651400	632700	6283	31583	0.5117	0.5091
112	RUGBY GROUP	20680	20130	670	1916	0.4592	0.4768
113	SAINSBURY (J)	6067	212400	1974	29771	0.3136	0.5040
114	SANDERSON,BRAMALL.	0	0	8	39	0.0281	0.3179
115	SAVOY HOTEL 'A'	5631	1817	208	2269	0.0516	0.1247
116	SCAPA GROUP	9054	36997	271	2173	0.5204	0.5489
117	SCOT.& NEWCASTLE	58075	206900	1621	14109	0.2778	0.3626
118	SCOTTISH T.V.	3	282	32	390	0.3647	0.3847
119	SEARS	124094	237200	3229	16718	0.4028	0.5714
120	SENIOR ENGR.	1765	24530	186	829	0.3442	0.4253
121	SHELL TRANSPORT	1408800	1358000	30309	36569	0.3033	0.4656
122	SIDLAW GROUP	3012	9342	46	285	0.1194	0.1583
123	SIEBE	3813	211468	200	7539	0.3437	0.3956
124	SIGNET GROUP	556	80222	132	2850	0.3312	0.4170
125	SILENTNIGHT HDG.	1875	565	135	643	0.2121	0.1894
126	SIMON ENGR.	10696	12179	556	1783	0.5044	0.5032
127	SIRDAR	621	200	79	561	0.3189	0.4145
128	SKETCHLEY	1396	36057	224	1487	0.3234	0.3574
129	SMITH (DAVID S)	0	25823	38	2201	0.2679	0.4158
130	SMITH(WH)GROUP	7208	136172	1011	3754	0.4394	0.5779
131	SPIRAX-SARCO	3127	6591	334	1323	0.4513	0.4802
132	STAKIS	4932	32608	145	2371	0.3768	0.3819
133	STERLING INDS.	350	478	46	320	0.1889	0.1953

Appendix B -- Continued.

No.	Name	Debt (1979)	Debt (1988)	MV (1979)	MV (1988)	APT r_a^2	LAPT r_a^2
134	STYLO	3477	14140	61	491	0.1279	0.2487
135	I & N	98350	96100	1706	4091	0.3370	0.3413
136	TARMAC	40053	398700	909	16260	0.5474	0.6509
137	TATE & LYLE	124200	813100	818	6081	0.4216	0.4484
138	TAYLOR WOODROW	33690	123700	938	9064	0.4914	0.4809
139	TESCO	379	236900	1675	18964	0.3668	0.5150
140	THORN EMI	25600	185300	4968	17017	0.4626	0.4746
141	TI GROUP	135400	103100	2102	5551	0.5051	0.5258
142	TILBURY DOUGLAS	0	128	54	680	0.2129	0.1871
143	TIME PRODUCTS	358	205	271	943	0.3532	0.3384
144	TOMKINS	19	85192	48	2837	0.1833	0.3146
145	TRAFALGAR HOUSE	171877	358700	1275	14470	0.4400	0.5151
146	TRANSPORT DEV	27584	66164	903	3446	0.4928	0.5135
147	TRANSTEC	5256	550	204	248	0.1646	0.3427
148	TRINITY INTL	1511	9025	125	201	0.4135	0.5690
149	TRIPLEX LLOYD	613	3344	68	402	0.2357	0.3293
150	TT GROUP	47	1247	7	163	0.1995	0.4027
151	UNIGATE	70194	90300	1494	7977	0.3635	0.4615
152	UNILEVER	784800	993000	9628	37247	0.5382	0.5225
153	UNITECH	459	13596	228	867	0.4847	0.5645
154	UNITED NWSP.	1990	186950	214	6814	0.4253	0.4003
155	VAUX GROUP	12770	40290	377	[illegible]	0.3587	0.4033
156	VIBROPLANT	100	15387	124	106	0.1831	0.3129
157	VICKERS	76499	67300	809	4036	0.5301	0.5636
158	VOLEX GROUP	2080	1816	166	541	0.2895	0.2701
159	WADDINGTON (J)	1943	7624	133	1450	0.2229	0.2320
160	WAGON IND.HDG.	614	2818	145	638	0.3261	0.4490
161	WALKER GREENBANK	0	5688	21	677	0.1806	0.1850
162	WATMOUGHS HDG.	96	13204	39	526	0.2557	0.4107
163	WATSON & PHILIP	159	714	40	306	0.2397	0.2614
164	WATTS,BLAKE,BEA.	961	873	157	658	0.3074	0.3594
165	WEW GROUP	1100	2121	56	82	0.2383	0.2289
166	WHITBREAD	159031	421900	2191	12412	0.2846	0.4713
167	WILSON(CONNOLLY)	4175	13771	67	1395	0.3884	0.5211
168	WIMPEY (GEORGE)	90638	194200	1843	7240	0.4815	0.5440
169	WOLSELEY	1885	64341	275	4866	0.4266	0.4989
170	WOLSTENHLME RNK	0	6298	65	249	0.1279	0.2310
171	WOLV.&DUDLEY	239	75	359	2748	0.4351	0.4961
172	YORKS.CHEMICAL	5893	2225	117	415	0.2893	0.2912

Note - 1. Debt represents company long-term liability which is in thousands of pounds.
2. MV(1979) represents Market Capitalisation at the beginning of the testing period, January of 1979. MV(1988) represents Market Capitalisation at the end of the testing period, December of 1988, which is in the one hundred thousands of pounds.

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