POLITICAL AND ECONOMIC EVENTS 1988 TO 1998: THEIR IMPACT ON THE SPECIFICATION OF THE NONLINEAR MULTIFACTOR ASSET PRICING MODEL DESCRIBED BY THE ARBITRAGE PRICING THEORY FOR THE FINANCIAL AND INDUSTRIAL SECTOR OF THE JOHANNESBURG STOCK EXCHANGE

by

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SUMMARY

The impact of political and economic events on the asset pricing model described by the arbitrage pricing theory (APTM) was examined in order to establish if they had caused any changes in its specification. It was concluded that the APTM is not stationary and that it must be continuously tested before it can be used as political and economic events can change its specification. It was also found that political events had a more direct effect on the specification of the APTM, in that their effect is more immediate, than did economic events, which influenced the APTM by first influencing the economic environment in which it operated.

The conventional approach that would have evaluated important political and economic events, case by case, to determine whether they affected the linear factor model (LFM), and subsequently the APTM, could not be used since no correlation was found between the pricing of a risk factor in the LFM and its subsequent pricing in the APTM. A new approach was then followed in which a correlation with a political or economic event was sought whenever a change was detected in the specification of the APTM. This was achieved by first finding the best subset LFM, chosen for producing the highest adjusted R^2, month by month, over 87 periods from 20 October1991 to 21 June 1998, using a combination of nine prespecified risk factors (five of which were proxies for economic events and one for political events). Multivariate analysis techniques were then used to establish which risk factors were priced most often during the three equal subperiods into which the 87 periods were broken up.

Using the above methodology, the researcher was able to conclude that political events changed the specification of the APTM in late 1991. After the national elections in April 1994 it was found that the acceptance of South Africa into the world economic community had again changed the specification of the APTM and the two most important factors were proxies for economic events.

KEY TERMS

arbitrage pricing theory; arbitrage pricing model; arbitrage pricing theory model, non-linear asset pricing model; linear multifactor model; iterated nonlinear seemingly unrelated regression; nonlinear three stage least squares; macroeconomic and financial factors; financial and industrial sector of the JSE

OWN WORK DECLARATION

I declare that:

POLITICAL AND ECONOMIC EVENTS 1988 TO 1998: THEIR IMPACT ON THE SPECIFICATION OF THE NONLINEAR MULTIFACTOR ASSET PRICING MODEL DESCRIBED BY THE ARBITRAGE PRICING THEORY FOR THE FINANCIAL AND INDUSTRIAL SECTOR OF THE JOHANNESBURG STOCK EXCHANGE

is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

..... 15/9/1999.....

SIGNATURE **DATE**

(MR CM STEPHANOU)

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CHAPTER 1
THE PROBLEM AND ITS SETTING

1.1 STATEMENT OF THE PROBLEM

This thesis studies the impact of political and economic events on the specification of the nonlinear multifactor asset pricing model, described by the arbitrage pricing theory, for the financial and industrial sector of the Johannesburg Stock Exchange before and during South Africa's transition to normality (1988-1998) which was heralded by the unbanning of the African National Congress and the release of Nelson Mandela in February 1990.

1.2 THE SUBPROBLEMS

The first subproblem is to establish whether the impact of political and economic events changed the specification of the linear factor model described by the arbitrage pricing theory for the financial and industrial sector of the JSE, during the period from 1988 to 1998.

The second subproblem is to confirm that any change in the specification of the linear factor model is translated into a change in the specification of the nonlinear asset pricing model, described by the arbitrage pricing theory.

1.3 THE HYPOTHESES

The first hypothesis is that a different set of financial and macroeconomic variables will be specified in the linear factor model, assumed by the arbitrage pricing theory, for the period before and after a regime switch caused by an economic or political event (events).

The second hypothesis is that any change in specification of the linear factor model will be translated into a change in the specification of the nonlinear asset pricing model, described by the arbitrage pricing theory.

1.4 THE DELIMITATIONS

The thesis will not attempt to explain the impact of every single political and economic event on the APTM, for reasons provided in chapter 4.

The thesis will be limited to the financial and industrial sector of the JSE and will not include the mining and related sectors. Substantiation for this decision will be given in chapter 2.

Testing of the possible changes in the specification of the arbitrage pricing theory model will be confined to the use of the method where prespecified financial and macroeconomic variables are used. This method was chosen for reasons outlined in chapter 2.

1.5 DEFINITION OF TERMS

- **Arbitrage pricing theory.** This is a theory of asset pricing introduced by Ross (1976) which describes asset pricing in the absence of arbitrage opportunities.

- **Arbitrage pricing theory model.** This is a multifactor nonlinear asset pricing model which encompasses the restrictions imposed by the arbitrage pricing theory on the linear factor model.

- **Asset pricing model.** An asset pricing model is an economic model which fashions the relationship between an asset and the underlying variables that influence its value.

- **Capital asset pricing model.** This asset pricing model was developed by Sharpe, Lintner and Black and explains the return of an asset as a linear function of its covariance with the market portfolio.

- **Efficient market.** An efficient market is one in which share prices adjust rapidly to the infusion of new information and in which current share prices fully reflect all available information, including the risk involved.

- **Efficient portfolio.** This refers to portfolios in which it is not possible either to obtain a greater expected return without incurring greater risk, or to reduce the risk without decreasing the expected return.

- **Endogenous variables.** These are variables which form an inherent part of the system.

- **Exogenous variables.** These are variables which impinge on the system from the outside.

- **Linear factor model.** This is a model of a return-generating process where asset returns are represented in terms of their sensitivities to a certain number of factors.

- **Market portfolio.** This is the efficient portfolio which represents all assets to which risk is attached.

- **Regime switch.** This refers to a change in the specification of an asset pricing model.

- **Static capital asset pricing model.** This refers to the specific situation in which the asset's covariance with the market portfolio is treated as constant over time.

1.6 ABBREVIATIONS

2SLS: two-stage least square

3SLS: three-stage least square

ANC: the African National Congress

APT: arbitrage pricing theory

APTM: the arbitrage pricing theory model

ASI: the all-share index

EMR: excess returns on the market portfolio

F & I index: the financial and industrial index

I-NET: Intelligent Network (Pty) Ltd

IFP: Inkatha Freedom Party

ITNLSUR: iterated nonlinear seemingly unrelated regression

JSE: the Johannesburg Stock Exchange

LFM: Linear Factor Model

MPT: modern portfolio theory

MRA: multiple regression analysis

NP: National Party

NYSE: New York Stock Exchange

OLS: ordinary least squares

PAC: Pan African Congress

SACOB: South African Chamber of Commerce

SUR: seemingly unrelated regression

1.7 ASSUMPTIONS

The first assumption is that the conditions necessary for testing the validity of the APTM on the JSE are in place. These assumptions can be found in chapter 2.

The second assumption is that the data downloaded from the I-NET are free of any errors.

1.8 IMPORTANCE OF THE STUDY

Certain world trends have brought about a tremendous increase in the amount of money invested by the South African public on the Stock Exchange. Numerous investment schemes, such as options, warrants, smaller companies unit trusts, international unit trusts, mining and resources unit trusts, gold unit trusts, financial unit trusts, financial and industrial unit trusts and general equities unit trusts have made this possible. This has accentuated the relevance of any economic theory that could explain the relationship between risk and reward. Such a theory is known as the modern portfolio theory. The arbitrage pricing theory model is perhaps one of the most vital components of this body of knowledge.

The unbanning of the ANC and the release of Nelson Mandela on 11 February 1990 can be regarded as one of the most important milestones in the history of South Africa. It led to significant economic changes, such as the falling away of economic constraints relating to trade, investments and the movement of capital. Another consequence has been an increase in liquidity on the JSE. Studies have shown that the predictive power of economic factors over stock returns changes over time and tends to vary with the volatility of returns. It could therefore reasonably be expected that the specification of asset pricing models applicable on the JSE would change. The confirmation of any regime switch and the gaining of any knowledge on the nature of the mechanism of this regime switch form a major part of this thesis.

The identification of any structural changes in asset pricing models and the timing of these changes are economically important. A change in the structure of an asset pricing model will change the estimates of expected stock returns. This will affect

(1) the selection of portfolios
(2) the evaluation of portfolio performance
(3) the measurement of abnormal returns in event studies
(4) the estimation of the cost of capital

CHAPTER 2
REVIEW OF RELATED LITERATURE AND RESEARCH

2.1 INTRODUCTION

The emergence of stock exchanges in Western countries, such as the Netherlands and the USA, was a result of the need to finance trading ventures. The need to finance these trading ventures by the Dutch led to the formation of the NYSE in 1692, just as the need to finance the emerging gold mining industry on the Witwatersrand led to the formation of the JSE in 1887, by one Benjamin Woollman.

For the most of its existence the JSE has been associated with the image of a rough mining town and the belief is held by many that investing on the JSE is best left to people who enjoy gambling. In fact Hofmeyer (1988:32) claims that the public who invested in unit trusts during the period 1970 to 1986 barely managed to break even on their inflation-adjusted capital. This dismal performance, coupled with cases of blatant insider trading, and the flotation of companies in the mining sector that can at best be described as speculative, lent considerable credence to the attitude described above.

Very little research on asset pricing models on the JSE has been published – only 34 papers had been published by the end of 1997 (Sandler & Firer 1998:55).

The biggest breakthrough in understanding the relationship between risk and reward in buying and holding a security (share) in the USA occurred in the 1950s when Markowitz introduced a theory which provided rigorous mathematical justification for the time-honoured investment maxim that diversification is a sensible strategy for individuals who like to reduce their risks. This theory opened a whole new field of study called the modern portfolio theory (MPT). Although the most prominent asset pricing model devised in this field is the Sharp-Lintner-Black capital asset pricing model (CAPM), the arbitrage pricing theory model (APTM) makes fewer restrictive assumptions.

2.2 THE CAPITAL ASSET PRICING MODEL

Sharpe (1964) and others focused directly on the part of a security's risk that can be eliminated by diversification and the part that cannot. The systematic risk related to the market risk cannot be eliminated by diversification, whereas the unsystematic risk relating to factors peculiar to an individual security can be eliminated by diversification. Hence the CAPM asserts that every asset must be compensated only according to its systematic risk, which is defined as the covariability of the asset with the market portfolio.

The CAPM assumes that investors are concerned only with portfolio risk and expected returns, and concludes that the expected return on a security is linearly related to the returns on the market in the following way:

$$E(R_i) = R_f + b_i[E(R_m) - R_f]$$

where: $E(R_i)$ = the expected return on security i

$E(R_m)$ = the expected return on the market

R_f = the risk-free rate (usually the treasury bill rate)

bi = covariance $(R_i; R_m)$/variance (R_m)

The testability of the CAPM is compromised over the issue of the market portfolio. Roll (1977) argued that no portfolio adequately represents all risky assets in the market portfolio. The market portfolio is thus unobserved and a test of the CAPM using *ex post* data is ambiguous - it results only in testing the efficiency of a proxy portfolio used in lieu of the market portfolio in estimating the systematic risk.

Studies that have empirically examined the performance of the static version of the CAPM in explaining the cross-section of realised average returns support the view that it is possible to construct a set of portfolios with which the static CAPM is unable to explain the cross-

sectional variation in average returns among the different portfolios. In particular, portfolios containing stocks with relatively small capitalisation appear to earn higher returns on average than those predicted by the CAPM (Reinganum1981).

In their widely cited study, Fama and French (1992) provided evidence suggesting that the inability of the static CAPM to explain the cross-section of average returns that has been reported in the literature may be economically important. Using return data on a large collection of assets, they examined the static version of the CAPM and found that the "relation between market beta and average return is flat". Instead they found that the structure of returns is effectively predicted by price-book value (P/BV) ratios and size. They interpreted the P/BV and size variables as proxies for risk.

2.3 THE ARBITRAGE PRICING THEORY

The arbitrage pricing theory (APT) introduced by Ross (1976) provides another model for explaining the relationship between return and risk. The APT, like the CAPM, asserts that every asset must be compensated only according to its systematic risk. But unlike the CAPM, where the systematic risk of an asset is defined as the covariability of the asset with the market portfolio, in the APTM, the systematic risks are defined as the covariability with not only one factor, but also possibly with several economic factors.

2.3.1 The linear factor model

The APTM is based on the assumptions that

(1) Markets are perfectly competitive and frictionless.
(2) Investors are risk-averse wealth maximisers.
(3) Individuals homogeneously believe that the random returns for the set of n securities under consideration are generated by a k-factor process of the form:

$$R_{it} = E(R_{it}) + \sum_{k=1}^{K} b_{ik} f_{kt} + \varepsilon_{it} \qquad (2.1)$$

where :

R_{it} = actual returns earned by asset i in time period t, where i = 1,2 ... n and t = 1,2 ... T

$E(R_{it})$ = the expected rate of return of asset i for period t at the beginning of period t

f_{kt} = kth risk factor that impacts on asset i's returns, where k = 1,2 ... K. All risk factors have a mathematical expectation of zero, that is $E(f_{kt}) = 0$

b_{ik} = a coefficient that measures the sensitivity of R_{it} to movements in the common factor f_{kt}

ε_{it} = a stochastic error term specific to asset i in period t which measures unexplained residual return where $E(\varepsilon_{it}) = 0$; $E(\varepsilon_{it}\,\varepsilon_{jt}) = 0$ for all i = j and $E(\varepsilon_{it}\, f_{kt}) = 0$ (Ross 1976:342)

Elaborating on assumption 3 helps us to understand the intuitions underlying the theory.

The return of a traded security can be subdivided into two parts. The first part is the expected return, $E(R_{it})$, which shareholders anticipate (expect). The second part (U_{it}) is the part which is unexpected. The *ex post* return of the security can thus be written as follows:

$$R_{it} = E(R_{it}) + U_{it} \qquad (2.1a)$$

If we allow for the unexpected part of the return to be broken down into its undiversifiable (unsystematic) component and diversifiable (systematic) component, we can express 2.1a as follows:

$$R_{it} = E(R_{it}) + S_{it} + \varepsilon_{it} \qquad (2.1b)$$

where:

S_{it} = the (unexpected) returns of asset i generated in period t as a result of systematic risk factors

ε_{it} = the (unexpected) returns of asset i in period t as a result of unsystematic risk factors

A particular security may have a sensitivity to a number of factors such as interest rates, the ability of its managing director, and its relationship with the trade unions. However, an investor holding a diversified share portfolio need only be concerned about a limited number of factors. These are the factors that cannot be diversified away, and for which he or she requires a premium in order to bear the risk.

Thus the systematic portion of the share's unexpected returns can be decomposed into a cumulative contribution of a limited number of significant factors:

$$S_{it} = \sum_{k=1}^{K} b_{ik} f_{kt} \qquad (2.1c)$$

where:

f_{kt} = the kth risk factor that impacts on assets' or portfolio returns,
where $k = 1,2 \ldots\ldots K$ and $E(f_{kt}) = 0$

b_{ik} = a coefficient that measures the sensitivity of R_{it} to a unit movement in f_{kt} *ceteris paribus*

Substituting 2.1c into 2.1b allows an asset's *ex post* returns to be expressed as the linear model mentioned above:

$$R_{it} = E(R_{it}) + \sum_{k=1}^{K} b_{ik} f_{kt} + \varepsilon_{it} \qquad (2.1)$$

This equation is a return-generating process underlying equity returns and is void of economic theory. Note that this equation is not an equilibrium pricing relationship because no restrictions are placed on the constant (representing $E(R_{it})$) of this model. This allows two assets with identical sensitivities (b_{ik}s) to have differing expected returns (Sharpe 1984:23).

The factors (f_{kt}) in the LFM underlying the APT must be unexpected and systematic. Although the identification of priced multifactor asset pricing regressors is essentially an empirical issue, the theory does provide certain guidelines on the characteristics that these regressors should possess.

Berry, Burmeister and McElroy (1988:29) state the following:

> Economic variables that are legitimate risk factors must possess three important properties:
> (1) At the beginning of every period, the factor must be completely unpredictable to the market.
> (2) Each APT factor must have a pervasive influence on stock returns.
> (3) Relevant factors must influence expected return; i.e. they must have non-zero prices.

According to Van Rensburg (1995:47):

> In accordance with property 1, the APT factors constitute unexpected movements in certain economic variables. As a result expected movements in the macroeconomic variables have to be determined using either statistical techniques or economic arguments. Property 2 implies that only variables that have a non-diversifiable or "systematic" influence will be priced. Thus, it follows that candidate factors should comprise macro-economic variables and not firm-specific characteristics such as financial ratios.

Alexander, Sharpe and Bailey (1993:252-253) also described the nature of the factors as follows:

> Three primary criteria influence the choice of factors. Most importantly, selected factors should demonstrate a significant impact on many securities[1]...
> Second, selected factors should possess theoretical justification. Including factors based solely on past statistical relationships with security prices is a dangerous game. These relationships may simply be coincidental and may not persist in future...
> Finally, factors should be selected for which timely, accurate data are readily available. For example, the spread between high and low quality bond yields (a measure of investor risk aversion and default risk) is widely and accurately reported. Conversely, even though one might believe that changes in the personal savings rate have a significant impact on share prices, such information is notoriously inaccurate and undergoes constant revisions.

Alexander et al (1993) have established that the APT factors are unexpected movements in certain macroeconomic variables.

Van Rensburg (1996) selected the following factors for his study: unexpected movements in: (1) the (dollar) returns on the Dow-Jones index, (2) inflation expectations, (3) the gold price (in rand), (4) the term structure of interest rates, and (5) the "residual market factor" of Burmeister and Wall (1986).

Van Rensburg (1996:106) reported the following:

> The macroeconomic variables used as candidate factors in this study do not exhaust all of the variables that meet these a priori criteria. In unreported tests the all share index was regressed on the following variables:
> Unexpected movements in

1. inflation (percentage changes in the CPI)
2. the growth rate of manufacturing production
3. the growth rate of retail sales
4. the growth rate of the money supply (M3)
5. the rand/dollar exchange rate
6. the growth rate of building plans passed
7. (percentage changes in) the rand gold price
8. dollar returns on the Dow-Jones industrial index
9. inflation expectations
10. the term structure of interest rates

[1] This is equivalent to property 2 above.

In only the last four cases was a significant (contemporaneous) relationship found. Thus, invoking the *a posteriori* criterion that the factors should demonstrate a "pervasive" impact on securities, only these candidate factors were selected to proceed to the next level of testing.

Chen, Roll and Ross (1986) and Burmeister and Wall (1986) suggest a broad outline regarding which macroeconomic variables' unexpected movements are likely to be priced. They take as their starting point the following basic share valuation formula :

$$P_{it} = \sum_{t=0}^{\infty} \frac{E(CF_{it})}{(1+r)^t} \qquad (2.2)$$

where: P_{it} = the price of stock i at time t

E = the expectations operator given information at time t

CF_{it} = the cash flows (dividends or capital gains) accruing to shareholders of asset i at time t

r = the appropriate discount rate

In effect, the price of a share is equal to the net present value (NPV) of all expected cash flows accruing to the shareholder by virtue of his or her ownership of this asset. Referring to the valuation model above, it can be argued that any macroeconomic variable that affects either the numerator or the denominator of this equation will influence returns.

However, since the cash flow expectations also depend on the business cycle, an approach where business cycle variables such as earnings and dividend yield are considered, in addition to macroeconomic variables, should be adopted when selecting candidate factors.

2.3.2 The arbitrage pricing theory model

The central intuition of the APT is that all portfolios that satisfy the conditions of

(1) using no wealth and
(2) involving no risk
must earn no return on average.

Portfolios that satisfy conditions (1) and (2) are termed "arbitrage portfolios". To form an arbitrage portfolio that requires no change in wealth, the usual course of action would be to sell some assets and then use the proceeds to buy others. This can be represented mathematically as follows:

$$\sum_{i=1}^{n} w_i = 0 \qquad (2.2a)$$

where

w_i = the market value weighting of asset i

To obtain a risk-free arbitrage portfolio one has to eliminate both diversifiable (ie unsystematic or idiosyncratic) and undiversifiable (ie systematic) risk. This can be done by meeting three conditions:

(1) selecting percentage changes in investment ratios, w_i ,that are small
(2) diversifying across a large number of assets
(3) choosing changes, w_i , in such a way that for each factor, k, the weighted sum of systematic risk components, b_k ,is zero. This condition can be more formally stated as:

$$\sum_{k=1}^{K} w_i b_{ik} = 0 \qquad (2.2b)$$

Finally, the no positive expected returns condition can be stated as:

$$E(R_{pt}) = \sum_{i=1}^{n} w_i E(R_{it}) = 0 \qquad (2.2c)$$

Equations 2.2a, 2.2b and 2.2c are really statements in linear algebra. Any vector that is orthogonal to the constant vector, that is,

$$\left(\sum_{i=1}^{n} w_I \right) . \mathbf{e} = 0,$$

and to each of the coefficient vectors, that is

$$\sum_{k=1}^{K} w_i b_{ik} = 0 \text{ for each k,}$$

must also be orthogonal to the vector of expected returns, that is,

$$\sum_{i=1}^{n} w_i E(R_{it}) = 0,$$

An algebraic consequence of this statement is that the expected return vector must be a linear combination of the constant vector and the coefficient vectors. Algebraically, there must exist a set of k + 1 coefficients, λ_1 , λ_2 ,.. . . ., λ_k such that

$$E(R_{it}) = \lambda_{0t} + \sum_{k=1}^{K} b_{ik}\lambda_k \qquad (2.3)$$

A natural interpretation of this equation is that λ_{0t} = the return on a risk-free asset (R_{it}) typically proxied by the three-month treasury bill. Substituting the expression for $E(R_{it})$ from the fundamental APT pricing relation (equation 2.3) into the linear factor model (equation 2.1) we obtain what Berry et al (1988:31) call the "full APT".

$$R_{it} = \lambda_{0t} + \sum_{k=1}^{K} b_{ik}\lambda_k + \sum_{k=1}^{K} b_{ik}f_{kt} + \varepsilon_{it} \qquad (2.4)$$

When compared to equation 2.1, it can be seen that restrictions have been placed on the intercept term of the linear factor model. These restrictions embody, and indeed are a direct algebraic consequence of, the no-arbitrage conditions.

2.3.3 Significant prior research done overseas

The APT has been studied empirically for close on two decades. Estimation methods for factors and factor loading remain a focus of research. The principal hypothesis of the model is that expected returns should be linearly related to the weights of the common factors in the assumed linear process. In every factor analysis test of the model the focus has been to use factor analysis to extract K factors from sample covariance matrices and then to test the hypothesis by regressing returns or average returns against the factor loading of the common factors.

Roll and Ross (1980) wrote what has become the classic article on testing the arbitrage pricing theory. Using data for individual equities during the 1962 to 1972 period, at least three and probably four factors are found in the generating process of returns. Roll and Ross (1980) used maximum likelihood factor analysis to estimate both the number of factors generating returns and the factor loadings.

In their critique on the empirical test described above, Dhrymes, Friend and Gultekin (1984) showed that there is a general nonequivalence between factor-analysing small groups of securities and factor-analysing groups of securities sufficiently large for the APT to hold. As one increases the number of securities to which the factor-analytic procedures are applied, the number of factors "discovered" increases and this result cannot be readily explained by a distinction between "priced[2]" and "nonpriced" risk factors.

In view of this criticism, the focus of the research has shifted to different multivariate analysis techniques (principal components, "mimicking portfolios" regression analysis, semi-autoregression approach), as well as to another approach suggested by papers by Chan, Chen and Hsieh (1985), Chen et al (1986) and Burmeister and McElroy (1988), which used macroeconomic factors such as unexpected inflation to explain asset prices in an APTM or multifactor model. The primary advantages of using measured economic factors are the following:

(1) In principle the factors and their APTM prices can be given economic interpretations, while in a factor-analysis approach one does not know what factors are being priced.
(2) Rather than using only asset prices to explain asset prices, measured macroeconomic factors introduce additional information, linking asset-price behaviour to macroeconomic events.

Chen et al (1986) correlated four macroeconomic variables in particular with returns on five portfolios that mimic the underlying factors. They were

(1) an index of industrial production
(2) changes in a default risk premium
(3) twists in the yield curve
(4) unanticipated inflation

[2] Priced factors are factors that are statistically significant.

Since these factor premiums cannot be constant, the above method evolved into a new approach which examined the relationship between overall economic conditions and time-varying risk premiums for a small group of portfolios as in studies by Keim and Stambaugh (1986), Chen (1991), Fama and French (1988), and Ferson and Harvey (1991).

McElroy and Burmeister (1988) used a nonlinear iterative estimation technique similar to the one that had been developed by Gallant (1975) to allow for the joint estimation of the β's and the asset risk premiums (λ's). Given that the factors are observable, the factor sensitivities and risk premiums in equation 2.4 can be estimated in three steps, as follows:

(1) Ordinary least squares (OLS) regression techniques are applied to equation 2.1 on a share-by-share basis, to yield estimates for $\{\beta_{i1}\lambda_1, \ldots\ldots \beta_{i\varphi}\lambda_\varphi\}$.

(2) The OLS residuals from fitting equation 2.1 share by share, which are denoted by $(e_{i1}, \ldots\ldots e_{it})$ for share i and $(e_{j1}, \ldots\ldots e_{jt})$ for share j, are then used to derive consistent estimates for S, the covariance term between ε_I and ε_j.

(3) A nonlinear feasible generalised least squares estimation technique is used to estimate λ_j and b_{ij} jointly based on the minimisation of a generalised least squares equation.

This entire procedure was performed using the ETS submodule of the SAS computer software package.

The study tested the significance of the four macroeconomic factors tested by Chen et al (1986) and the residual market risk factor. Using a sample of 70 firms, share returns were calculated from 1972 to 1982. Joint estimates of the risk premium of each factor and the sensitivity coefficients were determined by using the technique outlined above on individual shares. On average the five factors accounted for 24 percent of the returns on the individual shares and all five factors were priced.

The ITNLSUR method described above is superior to the two-stage approach used by Chen et al (1986) for the following reasons:

(1) In the Chen et al (1986) model, estimates from stage one (the asset betas) are used as inputs in the second stage. This introduces an "errors-in-the-variables" problem, where the errors that are produced in the first-stage estimates are compounded in the second stage, causing further errors and statistical problems. This problem is obviated because joint estimates of beta and the risk premiums are produced in one step by the McElroy and Burmeister (1988) approach.

(2) In the second stage in the method used by Chen et al (1986), portfolios that diversify away the unsystematic risk in the returns need to be derived in order to control the errors-in-the-variables problem. The McElroy and Burmeister (1988) analysis is performed on a share-by-share basis and does not require the construction of such portfolios.

(3) Little is known about the nature of the estimators of the Chen et al (1986) model or their characteristics (eg normality and consistency). Burmeister and Wall (1986:12) state that "these methods are known to give consistent estimates, but little else is known about the properties of the estimators". Thus the characteristics of the estimates produced and their accuracy and reliability are also unknown. The nature and characteristics of the estimates that are produced by the McElroy and Burmeister (1988) model are well documented. Gallant's nonlinear seemingly unrelated regression delivers "even in the absence of normally distributed errors, joint estimates of asset sensitivities and of risk 'prices' that are strongly consistent and asymptotically normally distributed and to which standard hypothesis testing applies" (McElroy & Burmeister 1988:29).

The robustness of the McElroy and Burmeister (1988) method in relation to the non-normality of the error distribution is an important consideration in South Africa because of the apparent absence of normality in returns on the JSE (Klerck & Du Toit 1986).

A number of studies have tried to integrate the more robust APT model with the CAPM. Tietman (1988) studied the conditions under which exact arbitrage pricing is compatible with the existence of a positive portfolio on the minimum-variance frontier and therefore (weakly) compatible with the CAPM. In his study, Wei (1988) combined the positive aspects of the APTM and CAPM models to derive a theory unifying both models. The derived results demonstrate that one need only add the market portfolio as an extra factor to the factor model in order to obtain an exact asset-pricing relation.

Jaganathan and Wang (1996) attempted to bridge the two models. They found that when the market index (against which beta is usually measured) is redefined to include human capital and when betas are allowed to vary with cyclical fluctuations in the economy, the support for the CAPM and beta as a predictor of returns is quite strong. This "conditional" CAPM is different from what is commonly understood as the CAPM, and resembles the multifactor APT model in that three betas are used whereas the standard CAPM has only one beta. Because of the "lagged premium factor" and the "labour-income-growth-rate factor" used, the model is known as the PL model (premium labour model). Although the conditional model performs better than the static model, caution is advised with regard to strong support for this conditional CAPM because of the "...somewhat *ad hoc* ..." (Malkiel,1996:270) procedures used to measure beta.

Fama and French (1996) adopted another approach. They found that a three-factor risk-return relation could explain the cross-sectional variation of expected returns. This model explained many of the average return anomalies not explained by the CAPM (such as size, earning/price (Basu 1983), cash flow/price, book-to-market equity, past sales growth, and long-term past returns). The model states that the expected return on a portfolio in excess of the risk-free rate is explained by the sensitivity of its return to three factors, namely:

(1) the excess return on a broad market portfolio
(2) the difference between the return on a portfolio of small stocks and the return on a portfolio of large stocks
(3) the difference between the return on a portfolio of high-book-to-market stocks and the return on a portfolio of low- book-to-market stocks

This model follows from their earlier work (Fama & French 1995) where they argued that firm size proxies for sensitivity to an unknown risk factor. They also found that small stocks have lower earnings on book equity than big stocks because, while both were harmed by the recession of 1981 to 1982, big but not small stocks benefited from the subsequent expansion. The finding presented by Thorbecke (1997) that monetary policy is a risk factor that has a large effect on small firms, coupled with the theoretical framework of Gertler and Gilchrist (1994) and the empirical evidence reported in Thorbecke and Coppock (1995), provides a possible explanation for Fama and French's results. Gertler and Gilchrist (1994) argued that a monetary tightening, by worsening balance sheet positions, could constrain the access of small firms to credit. They further argued that these credit constraints bind a larger number of small firms in a downturn, implying that changes in monetary policy should have a bigger effect on small firms in bad times than in good times. Building on this insight, Thorbecke and Coppock (1995) found that tight monetary policy during the 1981 to 1982 recession harmed both small and large firms, while easier monetary policy during the subsequent expansion benefited large, but not small firms. The evidence of an asymmetric response of small stocks to monetary shocks in recessions and expansions together with the finding that monetary policy is a common factor that has a big effect on small firms, suggests that it might be one of the state variables producing the size-related variation in returns discussed by Fama and French.

The Fama and French (1996) model was compared with the multifactor model specified by Jagennathan and Wang (1996), where it was found that R^2 for the Fama and French (1996) model was 55,12 percent (where R^2 is the fraction of the cross-sectional variation of average returns of 100 stock portfolios that can be explained by the model), which was comparable to the Jaganathan and Wang (1996) model. When tested, the multifactor model specified by Chen et al (1986) produced an R^2 of 38,96 percent while the static CAPM explained only one percent of the cross-sectional variation in average returns.

Paseran and Timmerman (1995) found that the predictive power of various economic factors over stock returns changes over time and tends to vary with the volatility of returns. The degree to which stock returns were predictable seemed quite low during the relatively calm

markets of the 1960s, but increased to a level where, net of transaction costs, they could have been exploited by investors in the volatile markets of the 1970s. They established a base set of nine potential forecasting financial and macroeconomic variables, and at each point in time, searched for a reasonable model specification capable of predicting stock returns across this set. They found that predictability of stock returns of a magnitude that is economically exploitable seems to depend not only on the evolution of the business cycle, but also on the magnitude of the economic shocks. Also, there does not seem to be a robust forecasting model, in the sense that the determinants of the predictability of stock returns in the USA seem to have undergone important changes throughout the period under consideration. The timing of the episodes where many of the regressors are included in the forecasting model seems to be linked to macroeconomic events such as the oil price shock in 1974 and the Federal Reserve Banks' change in its operating procedures during the 1979 to 1982 period. If they are correct in their conclusion that important episodes of predictability of stock returns are closely linked to the incidence of sudden shocks to the economy, then in analysing stock return predictability, it is advisable to use forecasting procedures that allow for possible regime changes.

Burmeister and McElroy (1988) first raised the possibility of the existence of "mimicking" portfolios. These are portfolios whose returns and factors are the same even though they have no residual risk. According to Brown (1988:734), the nonexistence of such portfolios is implicit in the ITNLSUR procedure and explicit in most of the other empirical examinations of the APT. A notable exception to this statement is the NL3SLS approach.

According to Burmeister and McElroy (1988:732):

> The potential application of the APTM to the study of economic structure, the allocation of risk and the relative factor sensitivities of firms within particular industries are indeed affected by the violation of the assumption.

Burmeister and McElroy (1988) presented their argument on the existence of "mimicking" portfolios (which is equivalent to regarding the market portfolio as an endogenous variable) by showing that unobserved (latent) macroeconomic factors should be included in the APTM.

Priestley (1996:884) agreed with this concept, but disagreed with the fact that Burmeister and McElroy (1988) constrain the variance-covariance matrix to be diagonal and by implication assume that the residuals of the "full APT model' are uncorrelated with one another.

In a further article, Clare, Priestley and Thomas (1997:645) state the following:

> In Ross's original version of the APT (Ross, 1976), the errors in the APT expected return equation are ignored by invoking the law of large numbers. This version of the model has become known as the *strict factor* version of the APT. Chamberlain (1983) and Chamberlain and Rothschild (1983) show that as the number of assets increase causing idiosyncratic variance to approach zero, there may be bounded correlations amongst idiosyncratic returns. In this case the results of Ross (1976) still hold. This version of the APT is known as the *approximate factor* version of the model and has been given intuitive appeal by Connor and Korajczyk (1993) who argue that:
>
> "It seems possible that a few firms in the same industry might have industry specific components to their returns which are not pervasive sources of uncertainty for the whole economy. For example, awarding a defence contract to one aerospace firm might affect the stock price of several firms in the industry. Assuming a strict factor structure would force us to treat this industry specific uncertainly as a pervasive factor (Connor & Korajczyk 1993:1264)."

The strict factor structure version of the APTM is estimated within the framework where the variance-covariance matrix of idiosyncratic returns is restricted to be diagonal (ITNLSUR approach).

Clare et al (1997) found that the APT is highly sensitive to the estimation technique used. Using the nonlinear three-stage least squares estimator (NL3SLS), where the variance-covariance matrix is restricted to be diagonal, they found that no factors are priced in the London Stock Market. However, when they estimated the model using the full, unrestricted variance-covariance matrix, they found five macroeconomic variables to be priced: a proxy for default risk; the retail price index; the yield on an index of UK debenture and loan stock; bank lending; and the return on the market portfolio.

These results were fully confirmed by Garrett and Priestley (1997) when they again found that returns are best described by an approximate market factor structure, and that when this is allowed for, six factors carry significant prices of risk. In contrast, when returns are constrained to have a strict factor structure, no factors carry significant prices of risk. Thus, the assumption about the behaviour of idiosyncratic returns is of crucial importance in terms of identifying the number of observed systematic risk factors that are priced.

To conclude, according to Seneque (1986:34), the APTM is less restrictive than the CAPM. He added that the APTM does not make use of the market portfolio concept and requires only that portfolios should be constructed using the factors to eliminate arbitrage profits - that is, that equilibrium conditions are established by ensuring that the "law of one price" holds for all possible portfolio combinations.
Copeland and Weston (1988:469) claimed that the APM (APT) is more robust than the CAPM for the following reasons:

(1) The APT makes no assumptions about the empirical distribution of asset returns.

(2) The APT makes no strong assumptions about individuals' utility functions (at least about nothing stronger than greed and risk aversion).

(3) The APT allows the equilibrium return of assets to be dependent on many factors, not just one (eg beta).

(4) Because the APT yields a statement about the relative pricing of any subset of assets, one need not measure the entire universe of assets in order to test the theory.

(5) There is no special role for the market portfolio in APT, whereas the CAPM requires that the market portfolio be efficient.

(6) The APT is easily extended to a multiperiod framework (see Ross 1976).

The major disadvantage of the APTM is that the factors affecting asset returns cannot be specified in advance. The model itself does not define the nature or identity of the macro-economic factors which explain asset returns.

2.3.4 Significant prior research done in South Africa

The South African output of research in the field of asset pricing models has been extremely modest - only 34 papers had been produced by the end of 1997 (Sandler & Firer 1998).

Gilbertson and Goldberg (1981) used the return on a mining index and an industrial index as two factors in a multifactor LFM. They compared the explanatory power of this model with that of the market model. However, they only examined three shares: East Driefontein Gold, Anglo American Corporation and Barlow Rand. They found that the beta coefficients of each of these sector indices were more statistically significant than the market model beta for all three shares, and that the two-factor model explained a greater percentage of share returns than the all-share index. The returns of each share were found to be related to different indices. For example, East Driefontein Gold's returns were related to returns on the mining index, Barlow's returns to the industrial index and Anglo American's to both indices. In other words, each share's returns were affected by the index, which in turn was affected by the same underlying macroeconomic forces. They thus concluded that a two-factor LFM would explain returns on the JSE better than the single-factor market model.

Page (1986) carried out empirical research into the APT model using data from the JSE. He found that at least two factors determine security returns rather than just the return on the market as predicted by the CAPM and that a two-factor APT model has significantly better explanatory powers than the CAPM in an *ex post* sense. His finding suggested that the underlying macroeconomic variables determining the return generation process can be divided into those that influence the mining sector to a greater extent and those that affect the industrial sector to a greater extent.

Using a factor-analysis approach, Barr (1990) identified the main economic forces which drive the various sectors of the JSE, such as the price of gold, the short-term rate of interest, the performance of foreign stock markets and local business confidence.

Davidson and Meyer (1993) report that with a few exceptions, the reported anomalies in overseas countries are absent on the JSE. The few market anomalies reported on the JSE are the Monday effect (Bhana 1985), the December effect (Bradfield 1990), the Public Holiday effect (Bhana 1994) and the P/E ratio effect (Page&Palmer 1991). Using multivariate tests on the CAPM, Bradfield and Affleck-Graves (1990) found that the CAPM cannot be rejected on the JSE, but more importantly that none of the additional factors, namely: firm size, dividend yield and liquidity, influence asset pricing on the JSE.

Reese (1993) studied the APT, employing a sample of 72 actively traded shares listed on the JSE for the period, 1980 to 1989. The ITSUR technique discussed in chapter 4 (sec 4.2.1) was employed to test the significance of the risk premium of each factor. Reese (1993) treated the mining and industrial sectors as two completely separate markets, performing separate APT studies on each sector. The APT test results for mining shares showed that the model with gold price risk and residual market risk and the model with growth rate risk and residual market risk had the highest adjusted R^2 values. However, these factors were not priced APT factors since they were not significantly different from zero. Four models were selected from the APT tests on industrial shares, on the basis of having the highest adjusted R^2 values and factors which were significantly different from zero. The four models were made up of the following risk factors: gold price risk and residual market risk; foreign exchange risk and residual market risk; inflation risk and residual market risk; default premium risk, gold price risk and residual market risk. She concluded that further work was required to identify APT factors operating on the JSE.

Van Rensburg (1996) attempted to identify the "priced" macroeconomic variables underlying percentage price movements realised by a representative sample of 72 non-thinly traded securities on the JSE over the period 01/01/1980 to 31/12/1989. Employing the ITNLSUR methodology of McElroy and Burmeister (1988), he found that unanticipated movements in the Dow-Jones industrial index, the term structure of interest rates and inflation expectations (as proxied by innovations in short-term interest rates) are associated with statistically significant and theoretically consistent risk premia over the period of the sample. In addition, the residual market factor, representing that variation in the JSE all-share index not explained by the above macrovariables, was priced and associated with a negative risk premium.

In their investigation of the relationship between domestic political news events and share market activity on the JSE, Van der Merwe and Smit (1997:21) found that the number of South African domestic political news events explains up to 59 percent of the volume traded as well as up to 23 percent of the movement of price (volatility) in the industrial index.

Beck (1995) found that share prices on the JSE had been largely affected by the perceived fortunes of the company concerned, and were relatively insensitive to sociopolitical factors within the country itself. He concluded that macroenvironmental factors appeared to influence the general health of the economy, and subsequently the share prices over a much longer time period than a single month.

Meyer (1998) used the APTM with a different number of factor indices (three, five and nine) as benchmarks in evaluating portfolio performance in South Africa. She found that, depending on the use of either CAPM or APTM benchmarks, average performance of passive portfolios was either better or not better than that of unit trusts for the ten-year period 1985 to 1995. She concluded that different benchmarks led to different results when evaluating portfolios.

Van Rensburg (1996:111) commented as follows on all the work done in South Africa on the APTM:

> Despite adopting essentially a factor analytic approach, Barr (1990) claims to ascertain the macroeconomic identity of the "pricing factors on the JSE". Employing the co-variance-bi-plot methodology, Barr observed which of a list of twelve pre-specified macrovariables accorded most closely with the first two (factor analytic) factors.
>
> However, despite its ingenuity, the methodology adopted by Barr is characterized by the following weaknesses:
>
> (a) Notwithstanding its graphical convenience for the co-variance-bi-plot, the assumption (no statistical testing was conducted) of two factors is not adequately justified. Citing Conway & Reinganum (1988) as evidence is misleading as their analysis was not conducted in the South African environment. Page (1986) did find two priced factors but the composition of Page's sample differs from that of Barr's in an economically meaningful way. Barr excluded all gold mining indices from his sample of 26 share indices. In contrast, Page explicitly observes

one of his (varimax rotated) factors being "composed exclusively of mining related shares" (1986:42). Excluding the gold indices from the sample "because initial research indicated that there was only one macroeconomic factor that dominated the pricing of gold securities in an obvious way, namely the gold price, and this effect tended to dominate the analysis" (1990:20) allows for more aesthetic results at the cost of misrepresenting reality. (Also note that despite its "obviousness", gold price risk was, in fact, found not to be priced in this study. Criticism (i) of Reese below is also of relevance here).

(b) No attempt was made to extract unexpected movements in the candidate macro-variables.

(c) It is not examined whether exposure to any of the prespecified macro-economic variables are associated with a significantly non-zero risk premium. This is the defining characteristic of a priced factor and without empirically examining this issue, no claim can be made to identify priced sources of macroeconomic risk.

Criticisms (a) and (c) together suffice to undermine the drawing of inferences from Barr (1990) regarding the macroeconomic identity of the priced APT factors on the JSE.

Reese (1993) proceeds on methodologically firmer ground by adopting the prespecified variable (rather than factor analytic) approach and uses the systems equation technique of McElroy & Burmeister to explicitly test whether the candidate macro-variables are able to explain the cross section of share returns. However, her study exhibits the following weaknesses:

(i) Reese conducts separate tests on the mining and industrial sectors of the JSE, taking into account the fact that different factors drive security prices in these sectors. However, even though mining shares' returns are likely to exhibit sensitivities to different factors other than industrial shares, this does not imply that different factors will be priced in each of these two markets. Through the diversification argument, attempts to find priced factors specific to particular industries are fundamentally misguided.

(ii) Reese identified the expected values of these variables by taking a moving average of the previous twelve months' values. These moving averages were subtracted from actual values of the macroeconomic variables in each period, to obtain a measure of unexpected movements in the macro-variables. Attempts to extract unexpected movements are unavoidably 'crude', however, Reese took no measures to ensure that her candidate factors had a mean of zero and were void of auto-correlation as equation (1) assumes. In fact, such is the nature of a moving average that it will systematically underestimate a variable if that variable is engaged in an upward trend and *vice versa.*

(iii) Unfortunately, Reese provided no synthesis of her findings pointing to some indication of a reasonable specification of the APT model. Rather, an array of varying combinations of factors that appeared to be priced in either the industrial or mining sectors was tabulated. In all cases, when the residual market factor was excluded from the analysis, the explanatory power of her models was prohibitively weak.

2.4 SUMMARY

There is overwhelming evidence to suggest that share returns on the JSE are affected by more than one financial and/or macroeconomic variable. It has also been shown that the APTM is superior to the static CAPM and that the pricing restrictions that it places on the LFM cannot be rejected.

Enough work has also been done on the JSE to confirm that it can be regarded as comprising two dichotomous sectors. This thesis has segmented the South African market and has concentrated on the industrial and financial sector to the exclusion of the gold mining and other related sectors. Since this sector (F & I index) fulfils the requirements of arbitrage (ch 2, sec 2.3.2.) and since the APTM is valid for any group of assets that fulfil this requirement, this approach is valid.

If Paseran and Timmerman (1995) are correct in their conclusion that important episodes of predictability of stock returns are closely linked to incidences of sudden shocks to the economy, of which South Africa has experienced many, then in analysing stock return predictability, we would have to use a model which allows for possible regime changes.

From the research that has been done both overseas and in South Africa, it would appear that the best method of testing the APTM is the approach where prespecified macroeconomic variables are used together with either the ITNLSUR and/or NL3SLS approach to jointly estimate the asset risk premiums and sensitivities. These models should be calculated on a recursive basis in order to capture the changes in the specification described in the previous section.

Because the JSE is largely free of the market anomalies (as discussed in the previous section) associated with the NYSE, the prespecified risk factors will resemble those proposed by McElroy and Burmeister (1988) rather than those of Fama and French (1996) and Ja gennathan and Wang (1996).

CHAPTER 3
RISK FACTOR, INSTRUMENT AND SHARE SELECTION

3.1 ESTIMATION OF CANDIDATE RISK FACTORS

3.1.1 Introduction

The most severe limitation of the APT is that the theory does not provide an explanation for the choice of macro-economic variables for use as factors in the model. The empirical work which attempted to identify the factors operating on the NYSE and JSE was summarised in chapter 2 (sec 2.3).

The factors to be tested are chosen from those suggested by economic theory and empirical studies of both the APT and related subjects. Since the particular interest of this study is the effect of political and economical events on the APTM, risk factors that could proxy for these events were sought.

Before this exercise was undertaken, a thorough study of the political and economic environment prevalent in South Africa during the period under consideration was carried out to gain perspective on the situation in question.

The following brief overview of the history of South Africa before 1988 is meant to provide a brief summary and does not necessarily reflect all the major events in the country's history, nor is it meant to be judgmental. This section draws on Tyson, Steyn, Gibson, Trail and Desai (1998).

As the period under consideration in this thesis extends from 1988 to 1998, a more detailed analysis of important political and economic events is needed on a year-to-year basis. In order to be consistent and nonjudgmental in the listing of important political and economic events, a respected and reliable single source of news events was sought. It was decided to use *The Economist*, a respected British political and financial weekly magazine, as the reference source.

Appendix 1 shows the annual index issued by *The Economist* from January 1988 to June 1998, listing all articles published by the magazine on South Africa for the year.

South Africa before 1988

The earliest settlers in the southern tip of Africa were the San people, who were gradually displaced by the Khoikhoi, after which the Bantu peoples started migrating southwards into the area from about 300AD.

The Portuguese explorers, Bartholomew Dias and Vasco da Gama, visited the Cape in the 16th century. The first white settlement was established by the Dutch East India Company (VOC) under Jan van Riebeeck at the Cape in April 1652. As this half-way station between Europe and the East Indies grew, the settlement was swelled first by the Huguenot refugees from religious oppression in Europe, then by slaves brought from Asia.

The Dutch settlement expanded during the 18th century and colonists spread out into the interior as farmers. In the Eastern Cape, the whites came up against the Xhosa. As competition for grazing land grew, the first of nine frontier wars erupted in 1779.

In 1775, during the French revolutionary wars, Britain annexed the Cape. Eight years later the colony reverted briefly to the Batavian Republic, the new name for the Netherlands under Napoloenic rule. In 1806 the Cape was re-occupied by Britain.

Concerned at the instability of the Eastern Cape frontier, the colonial government brought in 5000 settlers from Britain in1820. The British settlement and annexation of the Cape colony in 1806 helped stimulate the development of a strong sense of identity among the Afrikaners or Boers ("farmers") of broadly Dutch stock who responded with a series of northerly movements into the hinterland, culminating in what became known as the Great Trek. This movement led to battles between Afrikaners and Bantu groups, notably the Zulus, and to the formation of two Boer republics north of the Orange River: the Transvaal and the Orange Free State.

The discovery of diamonds in the northern Cape in 1867 and of gold on the Witwatersrand in 1866 changed the face of southern Africa. New immigrants flooded into the country, transforming a predominantly rural, pastoral land into a thriving industrial economy, based on mining. Johannesburg and its environs became the economic heartland of the country.

After the British victory in the Second Anglo-Boer War of 1899-1902 the two Boer republics were united with the Cape Colony and Natal and the Union of South Africa, a self-governing dominion within the British empire, was declared in 1910.

During the years between the declaration of the Union and the post World War 2 election of 1948, South Africa transformed itself into a modern industrial nation and began to give legal effect to the segregation of Black and White races that had always been inherent in South African society. Black dissatisfaction resulted in the formation of the African National Congress in 1912.

In 1948 the National Party, which represented Afrikaner Nationalism, won the election and came into power. Building on existing policies, this party devised a more rigid system of territorial, social and political segregation known as apartheid, which met with growing black resistance and with hostility from all parts of the post-war world.

Following the shooting of 69 people in a demonstration against "pass laws" at Sharpeville in 1960, the African National Congress and the Pan African Congress (an anti-apartheid organisation formed under Robert Sobukwe) were banned. In 1961, after a referendum had been held, the National Party withdrew South Africa from the British Commonwealth and declared it a republic.

The National Party's policy of apartheid was to build up the legal and political framework of a system which was designed ultimately to create a white state which could draw on the labour of a number of "black nations" (homelands) that would legally bind blacks to their rural land of ancestry. Four of these homelands, namely the Transkei, Bophuthatswana, Venda and Ciskei (the TBVC states) were declared independent although they were wholly

reliant on financial assistance from the central government and were never recognised by the government of any other country.

After the assassination of premier Hendrik Verwoerd in 1966, his successors BJ Vorster and PW Botha instituted some reform measures while tightening internal security. However, worker opposition, international sanctions and the growing economic interdependence of black and white in a modernising, urbanising economy combined to make the apartheid system increasingly untenable.

On 16 June 1976 schoolchildren in Soweto revolted, igniting a campaign of resistance designed to make the black townships and eventually the entire country ungovernable. By the 1980s the liberation of Africa had reached South Africa's borders after the collapse of Portuguese colonial rule in Angola and Mozambique and the independence of Zimbabwe. During this period tensions reached their highest ideological pitch. Under the presidency of PW Botha the government actively attempted to destabilise independent states in the region, especially the then communist governments of Angola and Mozambique. At home it mixed tight military control and artificial constitutional reforms with some genuinely reformist measures, such as a relaxation of the "pass laws" constraining black freedom of movement in urban areas, and the abolition of the Mixed Marriages Act in 1986. During the same year, the US Congress imposed sanctions against South Africa.

Although a detailed list of news events from January 1988 to July 1998 is given in Appendix1 the highlights are listed below:

South Africa: Political and economic events of 1988

Appendix 1 describes the following dominant events of this year:

- PW Botha bans 17 black organisations. February 1988
- Trade unions embark on a general strike. April 1988
- Government cracks down on political activity. October 1988
- Signing of Namibia/Angola peace deal. December 1988

- Zephania Mothopeng and Zwelakhe Sisulu released. Questions asked on date of Nelson Mandela's possible release. — December 1988

South Africa: Political and economic events of 1989

Appendix 1 describes the following dominant events of this year:

- PW Botha suffers a mild stroke. — January 1989
- PW Botha meets with Nelson Mandela. — July 1989
- PW Botha resigns, FW de Klerk new National Party leader. — August 1989
- National Party wins general election. — September 1989
- FW de Klerk becomes State President. — September 1989

South Africa: Political and economic events of 1990

Appendix 1 describes the following dominant events of this year:

- The African National Congress, the Pan African Congress and the South African Communist Party unbanned. — February 1990
- Nelson Mandela released after 27 years in prison. — February 1990
- FW de Klerk has talks with Nelson Mandela. — April 1990
- Suspension of armed struggle. The Pretoria Minute signed. — August 1990
- Winnie Mandela prosecution. — September 1990
- Reintegration of homelands. — December 1990

South Africa: Political and economic events of 1991

Appendix 1 describes the following dominant events of this year:

- Talks on new constitution stalled. — January 1991
- De Klerk promises to end apartheid. — February 1991

- African National Congress ultimatum to De Klerk. April 1991
- African National Congress-Government compromise. May 1991
- Population Registration Act repeal. June 1991
- America's trade embargo ended. July 1991
- Problem of African National Congress-Inkatha violence. November 1991
- Formation of Patriotic Front. November 1991

South Africa: Political and economic events of 1992

Appendix 1 describes the following dominant events of this year:

- Whites-only referendum endorses the Government's reform progress . March 1992
- Boipatong massacre, 39 people killed. June 1992
- Ciskei massacre. September 1992
- Mangosuthu Buthelezi secedes from talks. October 1992
- African National Congress/Government hold talks on multi-racial elections. December 1992

South Africa: Political and economic events of 1993

Appendix 1 describes the following dominant events of this year:

- Constitutional talks resume with 26 parties participating. March 1993
- Chris Hani, Secretary-General of the South African Communist Party, is assassinated. April 1993
- Afrikaner Volksfront formed to negotiate self-determination for Afrikaners. May 1993
- Constitutional compromises. July 1993
- Transitional constitution providing for non-racial democracy, three tiers of government and a justiciable Bill of Rights in a unitary South Africa is accepted. November 1993

- Beginning of Transitional Executive Council. December 1993

South Africa: Political and economic events of 1994

Appendix 1 describes the following dominant events of this year:

- Bophuthatswana uprising. February 1994
- Pre-election instability. February 1994
- End of election boycott by Inkatha Freedom Party. April 1994
- First non-racial election. April 1994
- African National Congress wins the election. May 1994
- Nelson Mandela inaugurated as South Africa's first black President. May 1994
- Chris Liebenberg, a respected banker, appointed as Finance Minister. May 1994
- John Major visits South Africa. September 1994
- Political tensions in KwaZulu-Natal. September 1994

South Africa: Political and economic events of 1995

Appendix 1 describes the following dominant events of this year:

- Fraud problems with two-tier exchange rate, possible scrapping. February 1995
- Winnie Mandela sacked from Government. April 1995
- Inkatha Freedom Party withdraws from Constitutional Assembly until international mediation is agreed on. April 1995
- Threats to Central Bank independence. June 1995
- Influx of foreign investment banks. August 1995

South Africa: Political and economic events of 1996

Appendix 1 describes the following dominant events of this year:

• Rand falls sharply after speculation about President Mandela's health.	April 1996
• Opening of Truth and Reconciliation Commission hearings.	April 1996
• National Party resigns from Government of National Unity.	May 1996

South Africa: Political and economic events of 1997

Appendix 1 describes the following dominant events of this year:

• Amnesty for political crimes cut off date is extended to 10 May 1994.	January 1997
• FW de Klerk resigns from politics. He is succeeded as leader of the National Party by Martinus van Schalkwyk .	August 1997
• Nelson Mandela steps down as African National Congress President and is succeeded by Thabo Mbeki.	December 1997

South Africa: Political and economic events, January to June 1997

Appendix 1 describes the following dominant event during the first six months of this year.

• Truth commission hearings continue.	January 1998

3.1.2 The selection of the nine risk factors

The researcher was particularly interested in ascertaining what effect the political and economic events described in the previous section had on the APTM, and risk factors that could proxy for these events were therefore sought.

Two studies were published in South Africa recently which sought to examine the effect of political and economic events on the Johannesburg Stock Exchange during the five-year period from 1990 to 1995 when South Africa was experiencing a particularly turbulent period in its history.

Van der Merwe and Smit (1997) found statistically significant coefficients of determination (R^2) to exist between domestic political news events and all-share index volatility, industrial index volatility and volume traded on the JSE.

Henn and Smit (1997) found that a number of South African economic news events have a weak negative and insignificant correlation significance with the movement in prices of shares traded on the JSE. Their finding that the number of news items with economic content have very little impact on share market volatility is not entirely unexpected. The number[1] of economic events were meant to proxy important events such as "the lifting of sanctions and abolition of the financial rand" (Henn & Smit, 1997:30), and to measure their effect on the JSE. Beck (1995) found that share prices on the JSE were not affected by macroenvironmental factors and that "these macroenvironmental factors appeared to influence the general health of the economy and subsequently the share prices over a much longer time period than a single month" (Beck 1995:35). This argument does not apply to the study by Van der Merwe & Smit (1997), who found a correlation between the number of domestic news events and the movement of shares on the JSE. "One explanation for these results could be that economic trends and results are more predictable than political news items and are therefore discounted beforehand in the share prices" (Henn & Smit 1997:33).

[1] Henn and Smit (1997:30) tested and confirmed that there is a relationship between the number of news events and the importance of such economic news events.

As important as the findings above was the way in which political and economic news events were quantified. Van der Merwe and Smit (1997:12) and Henn and Smit (1997:24) chose Reuter's News Services as their source for news events. They justified their choice on the grounds that Reuters has met the criteria for reliability as a source, has a proven track record of consistency and freedom from bias and is utilised by the majority of market participants in South Africa. They reported that the editorial staff of Reuters classifies news items into the following main categories: corporate affairs, economics, markets and politics. Each main category consists of further subsets.

The following are subsets in the economic news category:

(1) aid
(2) balance of payments
(3) consumer credit
(4) consumer finances
(5) consumer prices
(6) current prices
(7) current account
(8) economic output
(9) employment
(10) external trade
(11) government borrowing
(12) government finances
(13) housing starts
(14) monetary policy
(15) money supply
(16) performance
(17) personal income
(18) reserves
(19) retail sales
(20) wholesale sales

According to Henn and Smit (1997:26), "These sub-headings are all macro-economic related". As these subheadings are all macroeconomic related, each of the above 20 subheadings can be tested to establish if they can explain the movement of share prices traded on the JSE. Any risk factor found to be correlated with the movement of shares on the JSE could then be used as a proxy for economic news events. This procedure is undertaken later in this section.

The following are subsets in the political news category: defence, domestic politics, education, the environment, the European Union, foreign affairs, the Government list, and health and welfare.

Whereas the category of economic news events was found by Henn and Smit (1997) not to have any influence on the movement of shares on the JSE, Van der Merwe and Smit (1997) showed that the movement of share prices and the volume of shares traded on the JSE and the number of South African political news events were correlated. Therefore the volume of shares traded on the JSE could be used as a proxy for political news.

Rather than choose only risk factors that could proxy political and economic events in South Africa and then use a set number of these factors (nine) in this study, an alternative approach was considered. In this approach a wide selection of risk factors was made using the studies published in South Africa as a guideline and the choice was then narrowed down to the nine most important risk factors. This alternative approach was preferred to the obvious method of choosing only risk factors that could proxy for political and economic events for the following reasons:

(1) A risk factor such as the Dow Jones index has been shown to be important in all South African studies on the APTM. If a selection process had been used where only factors that can proxy political and economic events were chosen, this risk factor would not have been used, and as no other risk factor can explain the variation in returns on the JSE that the Dow Jones risk factor can, the results of the study would have been compromised.

(2) By using nine prespecified risk factors in our APTM we have made ample allowance for risk factors proxying political and economic events to be chosen in the final list of the nine most important risk factors.

(3) As the aim of this study is to identify the effect that political and economic events have on the JSE, risk factors that proxy these political and economic events need to be used in the APTM over 87 test periods in a combination that provides the maximum explanatory power over returns on the JSE. If this is not done there will be no benchmark for comparing the behaviour of these risk factors over time. In effect we will be measuring the behaviour of risk factors proxying political and economic events in an APTM (made up from a selection of the nine most important risk factors) which gives the maximum explanatory power over returns on the JSE.

In pursuance of the argument above, which requires the inclusion of as wide a selection of candidate risk factors as possible, the researcher reffered to the following studies published in South Africa on asset pricing models: Reese (1993) and Van Rensburg (1996).

In his study Van Rensburg (1996:106) used the following macroeconomic factors for testing the APTM on the Johannesburg Stock Exchange:

Unexpected movements in

(1) (percentage changes in) the rand gold price

(2) dollar returns on the Dow Jones industrial index

(3) inflation expectations

(4) the term structure of interest rates

Reese (1993:21) in her study on the effect of prespecified risk factors on share prices on the JSE used the unexpected movement in the following variables:

(1) foreign exchange risk

(2) default premia risk

(3) inflation rate risk

(4) gold price risk

(5) term structure of interest rates risk

(6) growth rate risk

Van Rensburg (1996) found three[2] risk factors priced in the APTM to be applicable on the JSE while Reese's (1993) results were inconclusive. The decision to use nine prespecified risk factors in this study would ensure that, as on average three would probably be priced during the period under consideration, the number and composition of priced risk factors varied significantly during the 87 periods during which the APTM was tested.

On the basis of the above arguments candidate risk factors were chosen using the list of 20 macroeconomic factors making up economic news, the proxy for political news, as discussed at the beginning of this section, and past studies done in South Africa on the arbitrage pricing theory model as a guide.

The following risk factors were eliminated because of the unavailability of data: aid, consumer credit, consumer finances, government finances and personal income.

When a risk factor could not be duplicated risk factors that were similar were used. Specifically, this meant using the seasonally adjusted value of building plans passed in constant terms instead of housing starts and gross domestic product at constant prices instead of economic output.

The list of 25 risk factors chosen is given below:

Unexpected movements in

(1) net long-term capital flow

(2) net short-term capital flow

(3) the index of export volume excluding gold

(4) the index of export volume including gold

(5) the index of import volume

(6) the rate of change in the three-month bankers' acceptance rate

[2] Excluding the residual market risk factor.

(7) the rate of change in the consumer price index
(8) the rate of change of the dollar/crude oil spot price (per barrel)
(9) the gross domestic product at constant prices
(10) the index of employment figures in the nonagricultural sector
(11) the index of pay per worker
(12) the index of productivity
(13) government borrowing
(14) the rate of change of the SACOB business confidence index
(15) the term structure of interest rates
(16) the money supply measure, M3
(17) gold and foreign exchange reserves
(18) the rate of change in the volume of shares traded on the JSE
(19) inflation expectations as represented by the one-time lag difference in the three-month bankers' acceptance rate (as used by Van Rensburg 1995)
(20) the rand gold price per ounce
(21) the US dollar/rand exchange rate
(22) the monthly number of companies placed in liquidation
(23) the rate of change of the Dow-Jones industrial index
(24) the rate of change of the dollar/gold price of one ounce of pure gold
(25) the rate of change of dividends in the financial and industrial sectors

Risk factors 1,2,3,4 and 5 proxy for the balance of payments, current account and external trade subsets of economic news.

Risk factor 6 proxies for monetary policy (as will be shown in sec 3.1.3.2 and also, together with risk factors 7 and 8, for the consumer prices and current prices subsets of economic news.

Risk factor 9 proxies for the economic output subset of economic news.

Risk factors 10, 11 and 12 proxy for the employment subset of economic news.

Risk factor 13 proxies for the government borrowing subset of economic news.

Risk factor 14, by virtue of its composition of thirteen indicators which are shown in section 3.1.3.2, proxies for the consumer prices, balance of payments, retail sales, external trade, monetary policy, employment, economic output, housing starts and personal income subsets of economic news.

Risk factor 15 proxies for the monetary policy subset of economic news.

Risk factor 16 proxies for the money supply subset of economic news.

Risk factor 17 proxies for the reserves subset of economic news.

Risk factor 18 proxies for political events.

Risk factors 19 to 25 are factors that have been used in previous studies on asset pricing models.

However, a number of risk factors had to be eliminated from the start because of the poor quality of the data available on them. The following ten risk factors were eliminated because data on them were available only on a quarterly basis:

(1) net long-term capital flow
(2) net short-term capital flow
(3) the index of export volume excluding gold
(4) the index of export volume including gold
(5) the index of pay per worker
(6) the index of employment figures in the nonagricultural sector
(7) the index of productivity
(8) the gross domestic product at constant prices
(9) the index of import volume
(10) government borrowing

After extracting the unexpected components of the 15 risk factors, a procedure that will be described in section 3.1.4, the following factors were subsequently eliminated because they exhibited substantial correlation with other risk factors:

(1) Inflation expectations as represented by the one-time lag difference in the three-month bankers' acceptance rate (as used by Van Rensburg 1995). This risk factor exhibited substantial correlation with the risk factor represented by the three-month bankers' acceptance rate.
(2) Rand gold price. This risk factor was eliminated because it was found to have a high correlation with the risk factor represented by the US dollar/rand exchange rate.

Returns on the financial and industrial sector were then regressed on the remaining 13 risk factors, using the stepwise regression method described by Pirow (1994:180) as follows:

$$R_{it} = c_0 + \beta_1 c_1 + \beta_2 c_2 + \ldots + \beta_{13} c_{13}$$

where:

R_{it} = return on the financial and industrial index
c_0 = constant
β_1 = sensitivity of risk factor 1
c_1 = unexpected component of risk factor 1
β_2 = sensitivity of risk factor 2
c_2 = unexpected component of risk factor 2

β_{13} = sensitivity of risk factor 13
c_{13} = unexpected component of risk factor 13

Our previous elimination of factors ensured that any correlation between pairs (or groups) of risk factors was eliminated. If this correlation is not removed, it may cause serious problems because it could produce misleading estimates of parameter values and result in totally

invalid statistical inferences. The risk factors shown above were added to the first risk factor one at a time a nd the R^2 statistic was used to classify the latest addition as

(1) useful
(2) detrimental
(3) superfluous

"Useful" variables were retained because they increase the "explanatory power" of the model. "Detrimental" and "superfluous" variables were excluded from the model for different reasons. The "detrimental" variables would cause a multicolinearity problem (a safety measure in case a problem had been overlooked), and the "superfluous" variables neither add any useful information nor cause any problems. This procedure was used to choose nine "useful" risk factors.

In other words, using this procedure, the researcher chose the most important nine risk factors according to their contribution to the overall R^2 statistic of the regression.

The four risk factors which were removed in this way were

(1) the US dollar/rand exchange rate
(2) the monthly number of companies placed in liquidation
(3) the money supply measure, M3
(4) gold and foreign exchange reserves

After this process of elimination, the nine candidate risk factors that were finally chosen were as follows:

Unexpected movements in
(1) the rate of change in the volume of shares traded on the JSE
(2) the rate of change of the SACOB business confidence index
(3) the rate of change of the Dow-Jones industrial index
(4) the rate of change of the dollar/gold price of one ounce of pure gold

(5) the rate of change in the three-month bankers' acceptance rate

(6) the term structure of interest rates

(7) the rate of change of dividends in the financial and industrial sectors

(8) the rate of change of the dollar/crude oil spot price (per barrel)

(9) the rate of change in the consumer price index

3.1.3 Risk factors chosen

Of the nine risk factors eventually chosen, six are effective proxies for political and economic events. Of these six risk factors, one proxies for political events and five for economic events.

The risk factor proxying for political events is the volume of shares traded on the JSE.

The risk factors proxying for economic events are:

(1) the rate of change in the three-month bankers' acceptance rate

(2) the rate of change of the US dollar crude oil spot price

(3) the rate of change in the consumer price index

(4) the term structure of interest rates

(5) the SACOB business confidence index

Three risk factors fall into the categories of corporate affairs and markets as used by Reuters. These are:

(1) the rate of change of the Dow-Jones industrial index

(2) the rate of change of the dollar/gold price of one ounce of pure gold

(3) the rate of change of dividends in the financial and industrial sectors

A tenth factor, namely the residual market factor, was chosen for inclusion in all the linear factor models (LFMs) for reasons explained in section 3.1.3.6, but essentially to ensure that the effects of all systematic risks in the market are measured when using the ITNLSUR technique.

The justification for choosing the above 10 risk factors, with corroborating evidence, as well as the way these factors are calculated, is outlined in the following sections. Note, however, that the descriptions of these factors are only partially complete. In order to extract the unexpected movement of these risk factors, procedures described in section 3.1.4 have to be undertaken.

3.1.3.1 A risk factor affected by the political climate

The risk factor proxying for political events is the volume of shares traded on the JSE.

a The rate of change in the volume traded on the JSE

Van der Merwe and Smit (1997) found statistical significance to exist between domestic political news events and all-share index volatility, industrial index volatility and volume traded on the JSE.

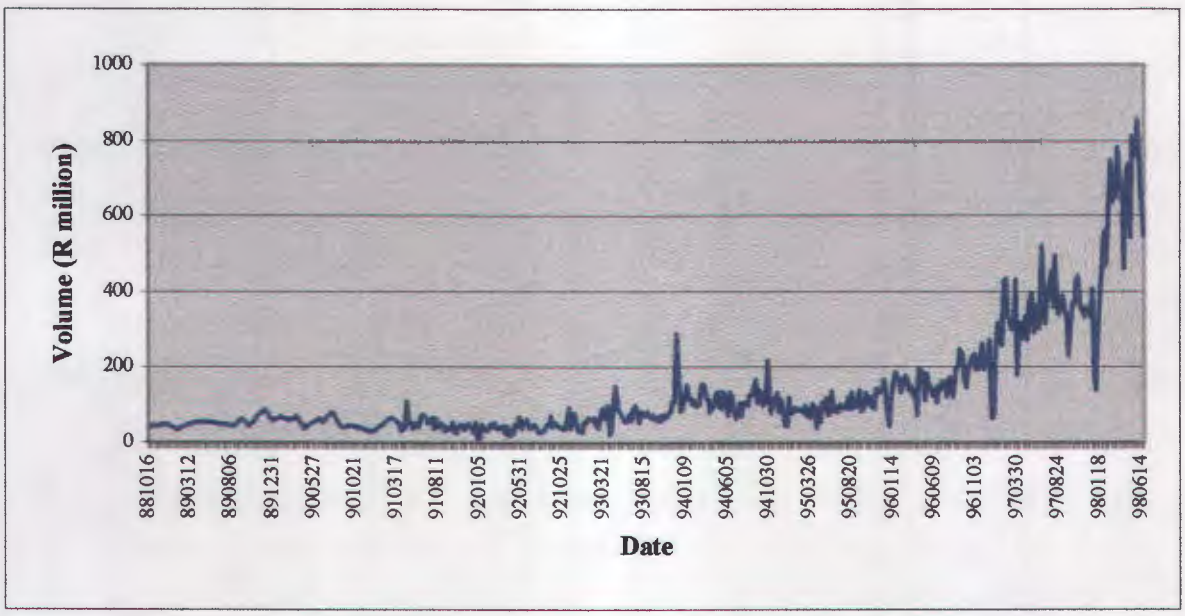
Van der Merwe and Smit (1997) tried to quantify the effect of domestic political events on the Johannesburg Stock Exchange. News events are reported daily by Reuters, which is an international news service provider. Van der Merwe and Smit (1997) isolated from the news released by Reuters daily items which were associated with domestic political events. They undertook this study over a five-year period (1990-1995) when South Africa was experiencing a particularly turbulent period in its history. When they compared the monthly number of political news releases with the volume of shares traded on the Johannesburg Stock Exchange, they found that South African domestic political news events explain 59 percent of the volume traded.

On the basis of the above evidence one would expect a relationship to exist between the volume of shares traded on the JSE and the political climate in South Africa. This would justify the selection of this factor as a proxy for political events in South Africa.

Graph 3.1 shows a plot of the weekly volume of shares traded on the JSE from 16 October1988 to 21 June 1998.

GRAPH 3.1

Weekly volume of shares traded on the JSE vs time from 16/10/1988 to 21/06/1998



It is interesting to note that the dramatic increase in the value of shares traded from 1995 onwards can be largely attributed to the introduction of the JET system of trading on the JSE. A combination of an influx of foreign investment banks (Appendix 1, August 1995), a change in regulations on the way business is conducted on the JSE (Appendix 1, November 1995) and the introduction of electronic trading helped tremendously to boost the volume of shares traded. This observation is not offered as a justification for including this risk factor as a proxy for political events but rather as a point of interest.

The rate of change of the volume traded on the JSE was calculated as follows:

$$PVOL_t = (VOL_t - VOL_{t-1})/VOL_{t-1}$$

where: VOL_t = volume of shares traded on the JSE at time t (R'000)

VOL_{t-1} = volume of shares traded on the JSE at time t-1 (R'000)

For reasons given in the previous chapter, the unexpected component of the risk factor was extracted from the rate of change in the risk factor.

3.1.3.2 Risk factors affected by the economic climate

The risk factors proxying for economic events are:

(1) the rate of change in the three-month bankers' acceptance rate
(2) the rate of change of the US dollar crude oil spot price
(3) the rate of change in the consumer price index
(4) the term structure of interest rates
(5) the SACOB business confidence index

a The rate of change of the three-month bankers' acceptance rate

The BA rate is the abbreviation for the bankers' acceptances rate which is the rate at which banks are willing to discount three-month bankers' acceptances. According to Mohr, Van der Merwe, Botha and Inggs (1995:6),

> A BA can therefore be formally defined as an unconditional written order addressed by a company (the **drawer**) to a bank (the **drawee**) that accepts to pay a particular amount at a specified future date to (or to the order of) the company. If the **bank** (drawee) accepts the above order, it signs it and becomes the **acceptor,** hence the term **bankers' acceptance.**

Nel (1994:20) observed that "...the general course and pattern of the BA rate after 1987 was to a greater degree in harmony with that of the Bank Rate than before this time." As the bank rate is controlled by the Reserve Bank the BA rate is in harmony with the official monetary policy of the Reserve Bank.

Correia and Wormald (1987) attempted to find a relationship between the contemporaneous rate of inflation as a proxy for expected inflation and returns on the JSE ASI during the period 1960 to 1986. They found no relationship, however, when utilising short-term interest rates as measures of inflationary expectations. Statistically significant results were found at the 95 percent level of confidence. They argued that changes in these interest rates are driven primarily by revisions in inflationary expectations.

The theoretical rationale for utilising short-term interest rates as measures of inflation expectations has its roots in the Fisher hypothesis:

$$R_{nt} = R_{rt} + E_t(\pi)$$

where: R_n = nominal three-month interest rate at time t

R_{rt} = real interest rate at time t

$E_t(\pi)$ = expected inflation over the next three months

Fama (1976) observed that the value of the real interest rate is relatively small and stable in comparison with inflation expectations. Van Rensburg (1995), in the light of the above argument, used the three-month bankers' acceptance rate to proxy for inflation expectations in his study of the APTM.

In light of the above empirical studies the BA rate qualifies as a proxy for economic events by virtue of the fact that it has been shown empirically to proxy inflation expectations and hence consumer prices, which by definition are a subset of economic events. However, in that it proxies the economic environment in another way - as illustrated by means of two examples - it is an even more powerful proxy for economic events.

Kusi (1993) examined South Africa's adjustment experience in the 1980s by quantifying the relative importance of demand management policies. He observed that the widespread threat of the imposition of sanctions on trade and investment in the mid-1980s and the refusal of foreign banks to defer repayments of short-term loans triggered the most serious balance of payments crisis that the country has ever experienced. In order to protect foreign reserves from capital outflows the authorities reintroduced the dual exchange rate system in September 1985[3]. To maintain large surpluses on the current account in order to accumulate foreign reserves to service the foreign debt the authorities placed more emphasis on domestic demand by

(1) introducing tariff protection measures
(2) introducing surcharges to reduce import demand
(3) taking steps to achieve a real depreciation of the rand exchange rate
(4) raising taxes

Kusi (1993:256) stated that "...the tax policy was supported by interest rate increases to control the money supply, thereby restricting domestic demand and dampening inflationary pressures."

[3] The two-tier exchange rate was abolished in February 1995 (Appendix 1).

After South Africa joined the world economic community it was in a position to run a deficit on its current account as it could rely on financing this deficit through the inflow of foreign capital. If this deficit is not covered by net capital flows it has to be covered by running down gold and other foreign reserves.

However, a continuous deficit on the overall balance of payments can have a drastic effect on money market interest rates. In 1996, for example, after a drop in the value of the rand (Appendix 1, April 1996) the sudden worsening in the balance of payments drained liquidity from the banking system, which in turn created a money market shortage. The Reserve Bank had two options for rectifying this situation, namely either to increase liquidity by injecting more money into the banking system (thus risking a consequent rise in inflation) or to increase the bank rate. As the Reserve Bank's position regarding inflation is to bring it down to the level of its foreign trading partners it chose to do the latter.

The above two examples confirm the assertion by Nel (1993:140) that since the mid-nineteen-eighties the monetary authorities have relied almost exclusively on the bank rate as the domestic instrument of monetary control[4].

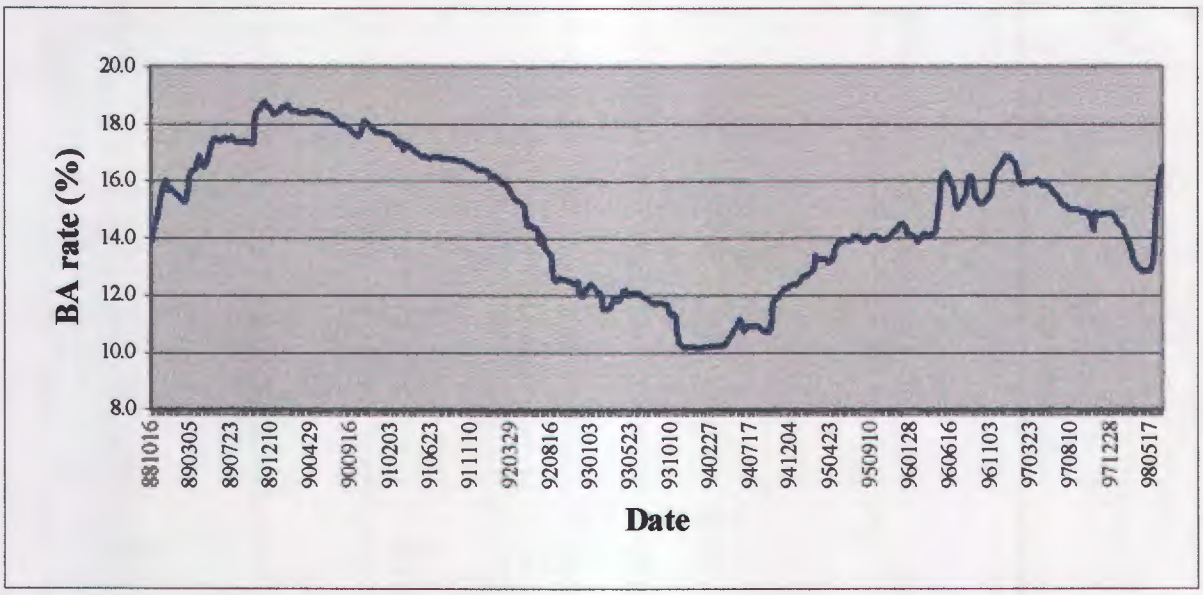
From the above arguments it can be seen that the BA rate is sensitive and thus can proxy inflation expectations and monetary policy, both of which are subsets of economic events.

Graph 3.2 shows a plot of the value of the BA rate from 16 October1988 to 21 June 1998.

[4] As the BA rate has been shown to be in harmony with the bank rate, this argument could apply to the BA rate.

GRAPH 3.2

BA rate vs time from 16/10/1988 to 21/06/1998



It is interesting to note that the behaviour of the BA rate curve tends to confirm the behaviour of this important financial variable during the various phases of the business cycle. During the upward phase of the business cycle (April 1986 to February 1989)[5], when monetary market conditions tightened towards the end of the second leg of the upswing, this was reflected by an upward trend in the BA rate. During the downward phase of the business cycle (March 1989 to May 1993)[5], when money market conditions eased, this was reflected by a downward trend in the BA rate as shown. From June 1993 to July 1995[6] the upward phase of the business cycle is reflected by an upward trend in the BA rate for the same period[7]. These observations do not contradict our assumption that the BA rate proxies for economic events. Since we are interested in extracting the unexpected component of a risk factor and using it in our APTM, the fact that the BA rate is susceptible to unexpected changes in the economic environment, as shown in our argument before, is what confirms our assessment that this risk factor proxies for economic events.

[5] These dates were officially confirmed by the Reserve Bank.
[6] This date is an estimate of the upper turning point of the business cycle made by ABSA Bank.
[7] Comparison between the business cycle and the BA rate after July 1995 is not possible, as any estimate of the behaviour of the business cycle would be speculative.

The rate of change in the three-month BA rate was calculated as follows:

$$PINT = (BA3_t - BA3_{t-1})/(BA3_{t-1})$$

where: PINT = the rate of change in the BA rate

$BA3_t$ = the three-month bankers' acceptance rate at time t

$BA3_{t-1}$ = the three-month bankers' acceptance rate at time t-1

Again, for reasons given in the previous chapter, the unexpected component of the risk factor was extracted from the rate of change in the risk factor.

b The rate of change of the US dollar crude spot oil price (per barrel)

Chen et al (1986) included inflation risk as one of the prespecified factors to be tested in their APTM analysis. The inflation factor was measured as the difference between actual and expected inflation for each period. Chen et al (1986) concluded that inflation risk was significantly different from zero, during the period from 1968 to 1977, but was insignificant before and after that period. The period of significance correlates roughly with the world oil crises and the resulting inflationary effects. In addition, the signs of the coefficients were mostly negative, which suggested to the authors that stocks were not performing as hedges against inflation.

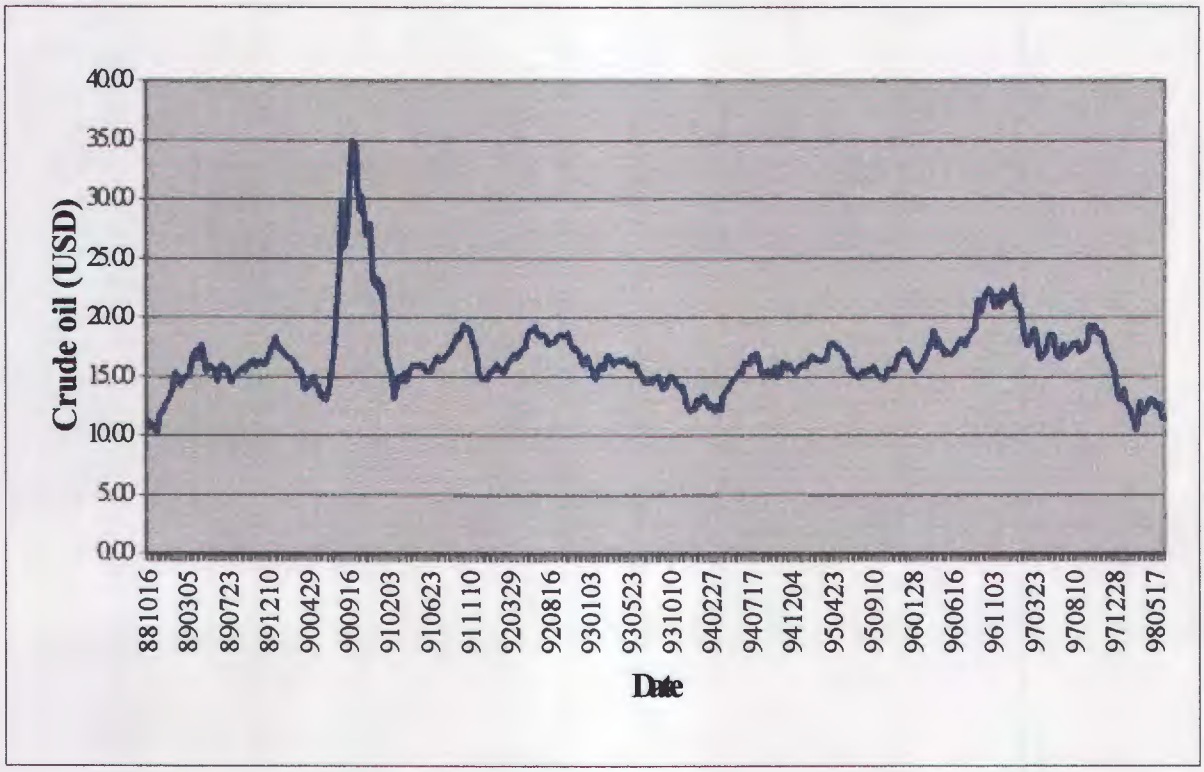
Roberts (1998) has shown that there is a high correlation between imported PPI and the year-on-year three-month led Dubai spot crude oil price. She added that although imported PPI makes up only about 20 percent of the PPI, because of the fact that prices are measured at the level of the first commercial transaction, the PPI can provide an indication of the most likely trend that consumer prices will follow.

To the extent that the price of crude oil was shown by Chen et al (1986) to proxy inflation and by Roberts (1998) to be sensitive to consumer prices, the selection of this risk is justified where it can proxy for consumer prices, which are a subset of economic events as described in section 3.1.2.

Graph 3.3 shows a plot of the US dollar Dubai spot crude oil price from 16 October1988 to 21 June 1998.

GRAPH 3.3

US dollar Dubai spot crude oil price per barrel vs time from 16/10/1988 to 21/06/1998



The sudden jump in the crude oil price in late 1990 was entirely due to the invasion of Kuwait by Iraq.

The gradual decline in the crude oil price from the end of 1996 onwards has helped the Reserve Bank to bring down inflation notwithstanding the drop in the value of the rand (Appendix 1, April and May 1996).

The rate of change of the US dollar/ crude oil spot price is measured as follows:

$$PCRUDE_t = (CRUDE_t - CRUDE_{t-1})/CRUDE_t$$

where: $CRUDE_t$ = US dollar Dubai crude oil spot price at time t (per barrel)

$CRUDE_{t-1}$ = US dollar Dubai crude oil spot price at time t-1 (per barrel)

Again, for reasons given in the previous chapter, the unexpected component of the risk factor was extracted from the rate of change in the risk factor.

c The rate of change in the consumer price index

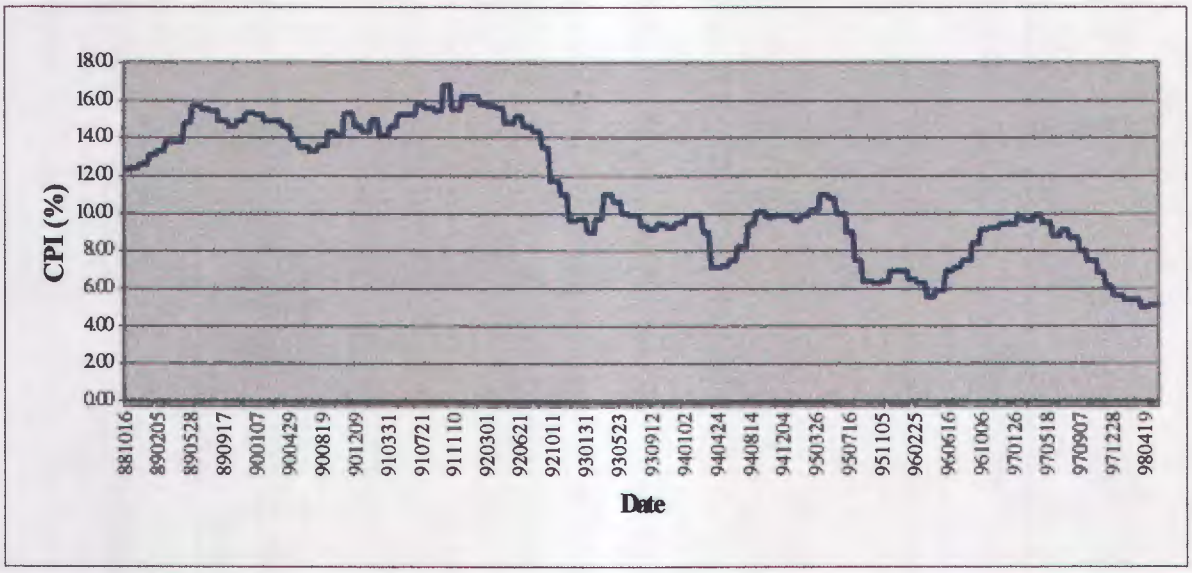
Even though Correia and Wormald (1987) found no relationship between returns on the JSE, the ASI and the current rate of inflation, this would be consistent with the APT model since only unexpected changes in inflation should be a factor. Reese (1993) adopted this attitude and used the unexpected percentage change in the consumer price index for all items in her study of the APTM in South Africa.

The same attitude is adopted here, but since there is a lag of two months in the publication of the monthly CPI figure, a two-month time lag is necessary when this variable is included in the data set. According to Paseran and Timmerman (1995:1208), this is standard practice in finance when dealing with such data.

Graph 3.4 shows a plot of the consumer price index (CPI) from 16 October1988 to 21 June 1998.

GRAPH 3.4

Consumer price index (CPI) vs time from 16/10/1988 to 21/06/1998



The selection of this risk is justified to the extent that consumer prices are a subset of economic events as described in section 3.1.2.

The rate of change in the consumer price index is therefore calculated as follows:

$$PCPI2_t = (CPI2_t - CPI2_{t-1})/CPI2_{t-1}$$

where: CPI2 = the two-month time lag figure for the consumer price index

$CPI2_t$ = CPI2 at time t

$CPI2_{t-1}$ = CPI2 at time t-1

Again, for reasons given in the previous chapter, the unexpected component of the risk factor was extracted from the rate of change in the risk factor.

d The term structure of interest rates

The relationship between short-term and long-term rates, on a particular day, on debt instruments that are alike in all characteristics except maturity, is known as the term structure of interest rates. This relationship is usually represented graphically as a yield curve.

Interest rate levels for short-term and long-term financial markets are determined independently by supply and demand in each market. This has the effect of shaping the yield curve.

An upward-sloping yield curve is regarded as a normal yield curve. Longer rates are usually higher than short-term rates to allow for the time and risks involved. However, the curve flattens or inverts when monetary conditions tighten.

During these periods, it is logical that many observers would come to expect the high and rising level of interest rates to push the economy into a recession which would subsequently cause interest rates to decline. The yield curve would flatten or invert at these times because observers were expecting interest rates to be lower in future. Because share prices are also driven by this influence, one would expect a close relationship to exist between the yield curve and share returns.

Nel (1994) found that the slope of the yield curve is positively related to the growth in the real GDP. Nel (1994:22) stated the following:

> If the short term rate is below the long term rate ... monetary policy is now accommodating and funds will be channelled into capital formation, providing momentum to the economic upswing. In the opposite case, which prevails around the peak and first section of the subsequent downswing in the business cycle, the bank's return on long-term lending is less than the cost of funds, with the result that lending is restricted.

In "The term structure of interest rates and economic activity in South Africa" Nel (1996) confirmed that the above description of the changes in the shape of the yield curve reflects the business cycle. Kaufman (1981) stated that this cyclical pattern of the yield curve is consistent with all three of the main term structure theories, namely the expectations, liquidity premium and market segmentation theories.

Nel (1996:169) concluded that:

> The ability of the yield curve to reflect future interest rate levels and (as in this paper) real economic activity, will amongst other factors, depend on the monetary control mechanism used in a particular country. If control is focused on short-term interest rates (which is presently the case in South Africa), and given that the long-term rate is largely market determined – the slope of the yield curve is basically the result of monetary policy.

As the "yield curve is basically the result of monetary policy" the term structure of interest rates is an effective proxy for monetary policy which is a subset of the economic news events.

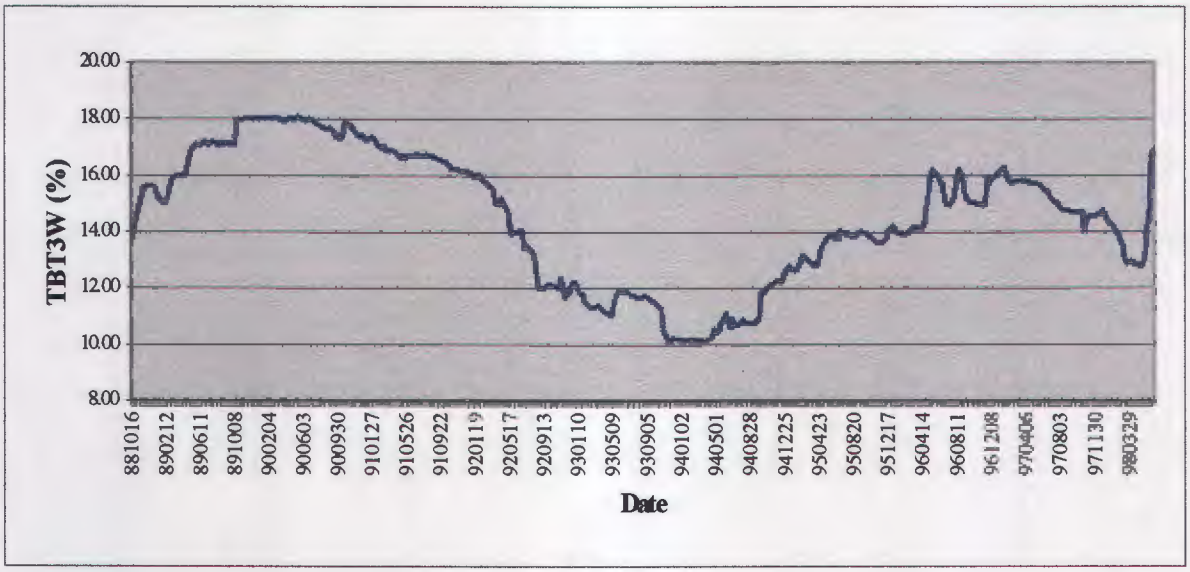
A measure of the term structure of interest rates was taken to be the difference in yields between three-month and 10-year default-free bonds.

	TS_t	=	$GILT10_t$ - TBILL
where:	TS	=	the term structure of interest rates
	GILT10	=	yield on 10-year government bonds
	TBILL	=	the yield on three-month treasury bills

Graphs 3.5 and 3.6 show plots of the 3-month treasury bill rate and the 10-year Government bond rate from 16 October1988 to 21 June 1998.

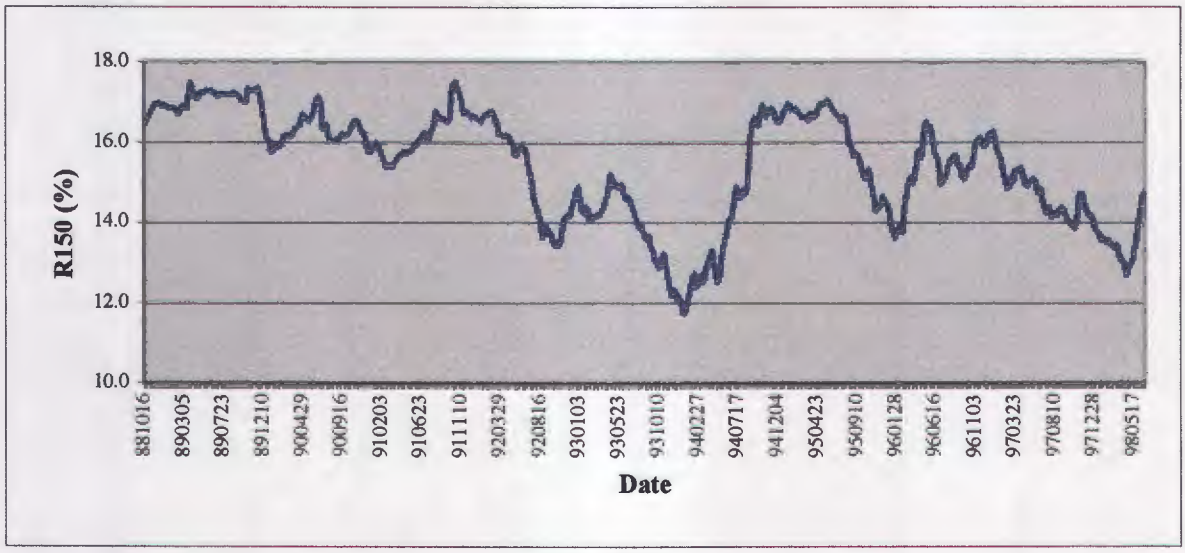
GRAPH 3.5

Three-month treasury bill rate vs time from 16/10/1988 to 21/06/1998



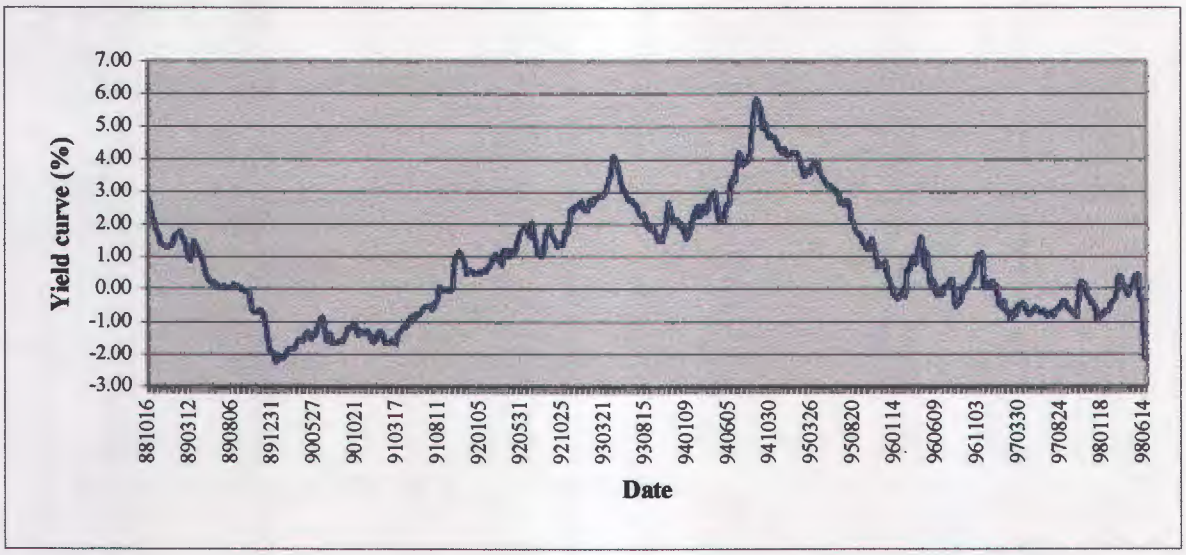
GRAPH 3.6

Ten-year government bond rate vs time from 16/10/1988 to 21/06/1998



GRAPH 3.7

Term structure of interest rates vs time from 16/10/1988 to 21/06/1998



It is interesting to note that following the rise in inflation (Appendix 1, September 1994) the Reserve Bank adopted a stricter monetary policy which caused the fixed interest market to become more attractive and subsequently caused the yield curve to invert as shown above.

In order to simultaneously eliminate nonstationarity, which is necessary for the subsequent time-series modelling, and obtain a measure of changes in this variable, the first difference of TS was taken:

$$TSD_t = TS_t - TS_{t-1}$$

where: TSD_t = changes in the term structure of interest rates at time t

e The rate of change of the SACOB business confidence index

Every month, the South African Chamber of Business (SACOB) publishes a figure which gives an indication of the business confidence prevailing in the country. SACOB'S index does not measure confidence specifically. SACOB's business confidence index (BCI) is a composite index, tracking the performance of 13 key economic indicators which have been judged by business to have the greatest bearing on the mood of businesses.

The following indicators currently make up the BCI:

(1) the average monthly exchange rate of the rand in terms of US dollars
(2) the rate of inflation, as measured by the consumer price index
(3) the three-month bankers' acceptance (BA) rate
(4) seasonally-adjusted retail sales in constant price terms
(5) the 12-month outlook of manufacturers on skilled and unskilled employment as reflected by SACOB's manufacturing survey – three-month moving average
(6) the gold price in dollar terms, as fixed on the London Metal Exchange
(7) merchandise imports in real terms
(8) merchandise exports in real terms
(9) the total number of new vehicles sold
(10) the physical volume of manufacturing production – seasonally adjusted
(11) the seasonally adjusted value of building plans passed in constant price terms
(12) the number of insolvencies of individuals and partnerships – seasonally adjusted
(13) the price of shares traded on the Johannesburg Stock Exchange as indicated by the JSE overall index

From the composition of this index it can be seen that with the possible exception of components (6) and (13), all other components fall under subsets of economic news. Component (1) falls under balance of payments, (2) under consumer prices, (3) under monetary policy, (4) under retail sales, (5) under employment, (7) and (8) under balance of payments, (9) under retail sales, (10) under economic output, (11) under housing starts and (12) under personal income. Both the physical composition of the SACOB BCI and the

primary function of this index of acting as a barometer of the economic environment justifies its selection as a proxy for economic news events.

Another index which measures business confidence is released monthly by the Stellenboch Bureau for Economic Research. This composite business confidence index canvasses sentiment among executives in the trade, manufacturing and construction sectors.

Managers of small and medium enterprises are asked, every month, to rank current business conditions as satisfactory or unsatisfactory. The response is measured on a scale of zero to 100, where zero reflects deep pessimism and 50 is neutral.

The decision to use the SACOB Business Confidence Index (BCI) instead of the Stellenbosch Bureau for Economic Research Composite Business Confidence Index was motivated to a large extent by the ability of this index to proxy for economic events. Futhermore as the SACOB BCI is more widely used and is available directly from I-Net , which was the data source used by the researcher for this study, it was decided to use this index in preference to the one provided by the Stellenbosch Bureau for Economic Research.

The SACOB BCI is compiled by the South African Chamber of Business (SACOB) and its primary function is to provide an indication of business confidence in the country for the information of the members of SACOB. In that SACOB's members are businessmen and are primarily interested in the economic ramifications of this index, its function is to interpret the effect of the economic environment on business confidence. This is reflected by the composition of this index, which is made up mainly of economic indicators.

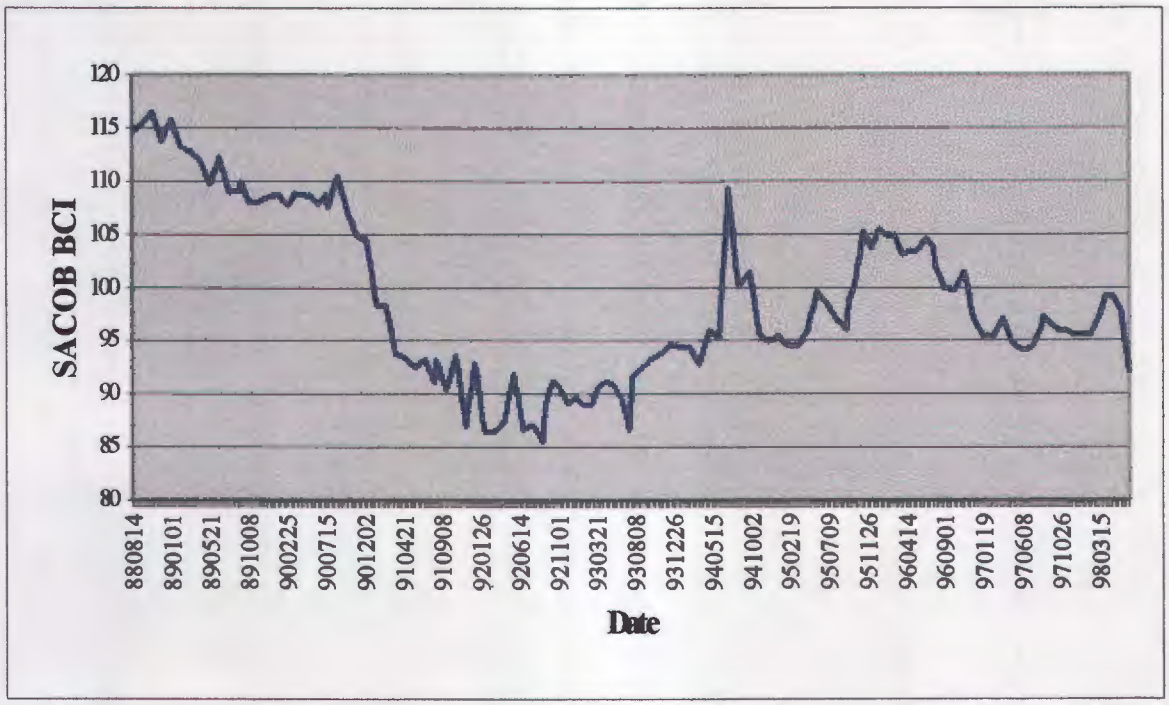
It is interesting to note that SACOB became an agent of political change between 1990 and the national elections in 1994. Their publication, *Business Voice*, stated in 1977 that they had done this by becoming an "honest broker" between the business community and the major political players at the time, namely the National Party government and the ANC. For example, they visited the ANC in Lusaka before it was unbanned in order to convey their views on the economy, they made representations to the ANC to present a case for the lifting of sanctions before the elections, they sent numerous delegations to the National Party

government and the ANC to persuade them to resume talks when negotiations foundered and they submitted various policy recommendations to all parties.

Graph 3.8 shows a plot of the SACOB BCI from 16 October1988 to 21 June 1998.

GRAPH 3.8

The SACOB BCI vs time from 16/10/1988 to 21/06/1998



As there is a lag of one month in the publication of the index, it is necessary to allow for a one-month lag when this variable is included in the data set. According to Paseran and Timmerman (1995:1208), this is standard practice in finance when dealing with such data.

The rate of change in the SACOB business confidence index is calculated as follows:

$$PSACOB1_t = (SACOB1_t - SACOB1_{t-1})/SACOB1_{t-1}$$

where: SACOB1 = the one-month lag in the SACOB BCI

$SACOB1_t$ = SACOB1 at time t

$SACOB1_{t-1}$ = SACOB1 at time t-1

Again, for reasons given in the previous chapter, the unexpected component of the risk factor was extracted from the rate of change in the risk factor.

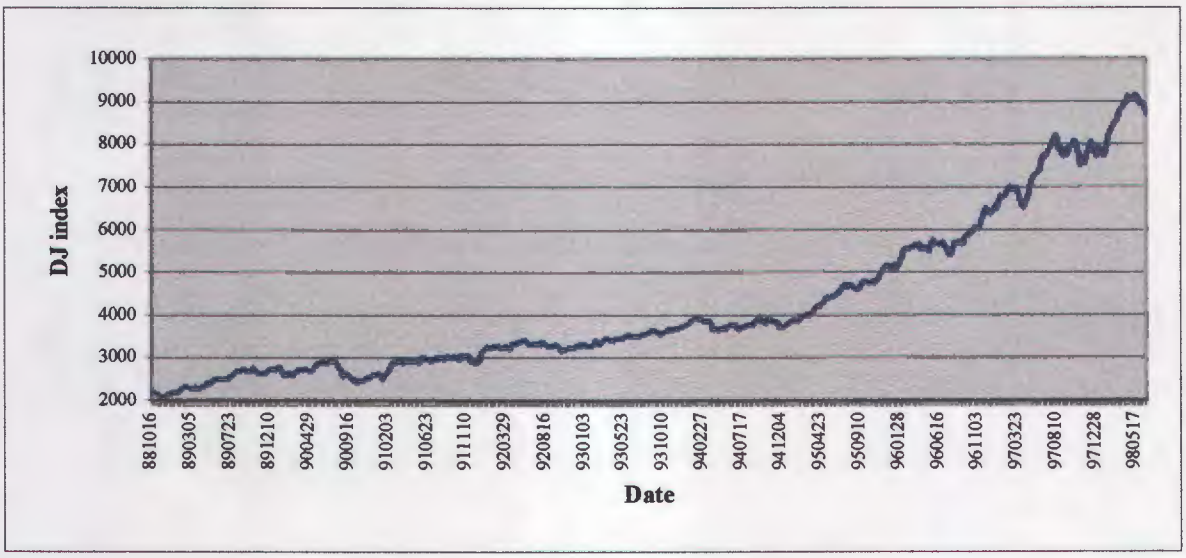
3.1.3.3 The rate of change of the Dow-Jones industrial index

There can be little doubt that a link exists between the stock markets of the world. Events such as the 1987 crash, which was an international phenomenon, lend support to this contention. Bradfield (1990:2) argues that the NYSE is the most internationally influential stock market. He substantiates this claim by observing that the NYSE index is the index most highly correlated with other international stock market indices. Bradfield (1990) investigated the influence of the NYSE on the behaviour of securities on the JSE. He found that 19 out of his sample of 30 randomly selected shares displayed statistically significant sensitivities to dollar returns on the Dow-Jones .

Graph 3.9 shows a plot of the Dow-Jones index from 16 October1988 to 21 June 1998.

GRAPH 3.9

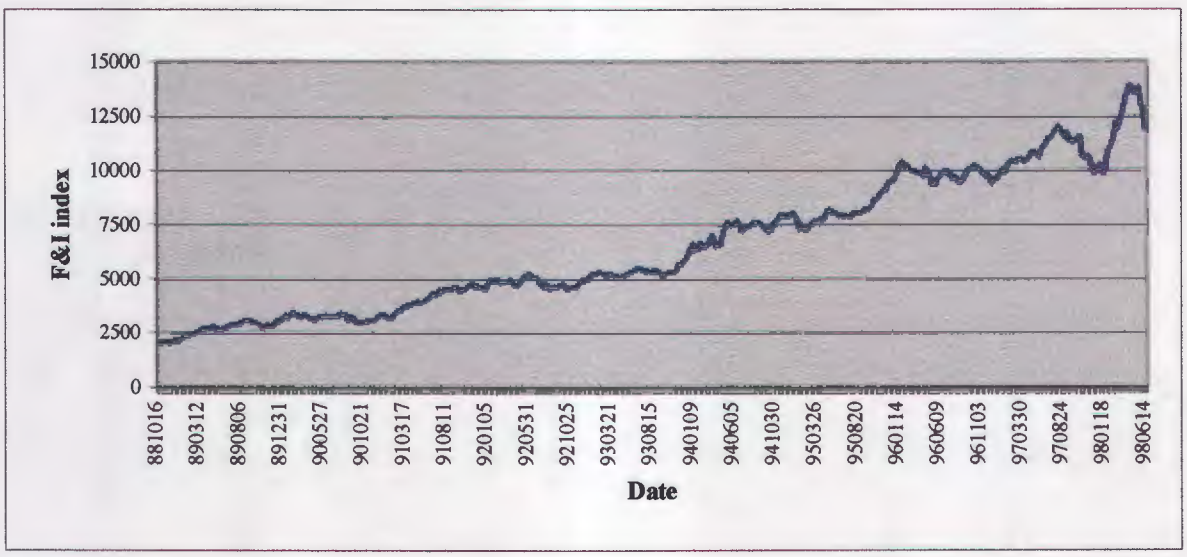
Dow-Jones industrial index vs time from 16/10/1988 to 21/06/1998



The close relationship between the Dow-Jones industrial index and the JSE is apparent when comparing graph 3.9 with graph 3.10, which shows the financial and industrial index of the JSE over the same period.

GRAPH 3.10

JSE, financial and industrial index vs time from 16/10/1988 to 21/06/1998



Accordingly, it was decided to utilise unexpected dollar returns on the Dow-Jones index as a potential factor. Returns on the Dow-Jones index were measured as follows:

$$PDJ_t = (DJ_t - DJ_{t-1}) / DJ_t$$

where: DJ_t = the value of the Dow-Jones index at time t

DJ_{t-1} = the value of the Dow-Jones index at time t-1

Again, for reasons given in the previous chapter, the unexpected component of the risk factor was extracted from the rate of change in the risk factor.

3.1.3.4 The rate of change of the US dollar gold price

The importance of the gold mining industry to the South African economy is well known and the relationship between the gold price and the profitability of this industry is indisputable.

It can be argued that the gold price will affect the numerator of the NPV valuation formula. Reese (1993:28) observes:

> Apart from the obvious impact of the higher gold price increasing the revenues of the mines ... the gold price affects the economy in several other different ways, in particular: as a direct stimulus to certain industries through demand for products to be used on the mines; as a substantial provider of foreign exchange; and as an important source of government revenue from taxation. The mining sector also attracts foreign resources, including capital and skills which can be used in the industrial sector and is an important employer. In addition, there is an indirect stimulus on the rest of the economy. This so-called "trickle-down" effect is caused by creating demand in other industries [due, for example, to wage disbursements to employees of the gold mining industry] and hence higher income.

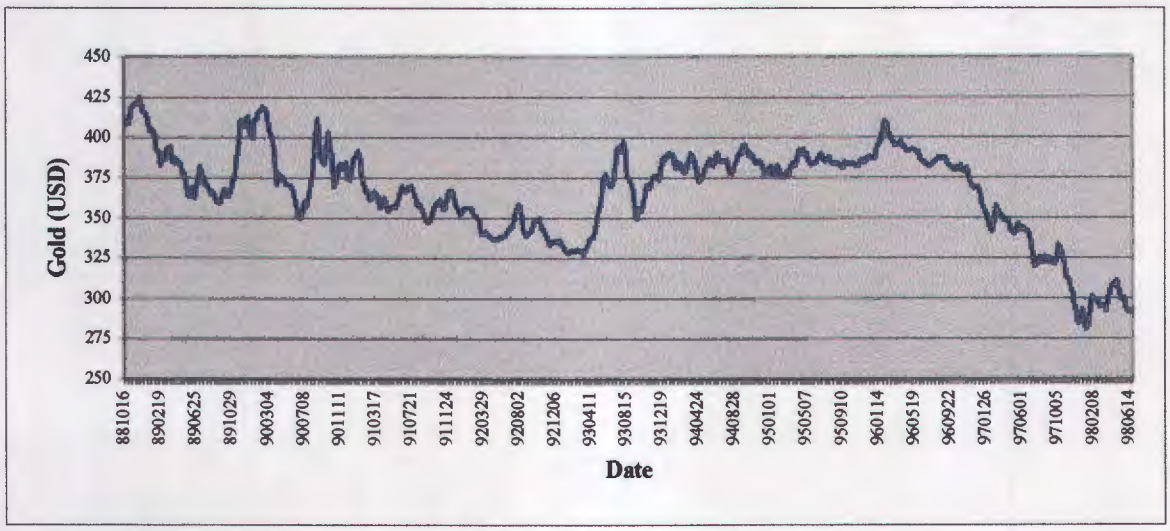
Barr (1990) applied the covariance-biplot methodology in an attempt to identify the macroeconomic variables which accord closely with the factors extracted on the JSE. He specifically excluded the shares comprising the all-gold index from his study in order to avoid allowing the gold price to dominate his analysis. He nevertheless found that the gold price correlated strongly with one of the two identified factors underlying industrial shares. This led Barr to propose that economic activity in South Africa is to a large degree driven by the levels of gold/metal prices through their direct effect on the mining sector and their

various filter-through effects on the rest of the economy. To the extent that the price of gold influences share returns, it was included as a risk factor.

Graph 3.11 shows a plot of the US dollar gold price per ounce from 16 October1988 to 21 June 1998.

GRAPH 3.11

US dollar gold price per ounce vs time from 16/10/1988 to 21/06/1998



As can be seen from the graph above, the gold price declined steadily from the beginning of 1997, reaching an 18-year low by the end of 1997, and causing a decline in the gold mining industry (Appendix 1, July 1997).

The rate of change in the dollar/gold price was measured as follows:

$$PDGOLD_t = (DGOLD_t - DGOLD_{t-1})/DGOLD_{t-1}$$

where: $DGOLD_t$ = the US dollar gold price at time t (per ounce)

$DGOLD_{t-1}$ = the US dollar gold price at time t-1 (per ounce)

Again, for reasons given in the previous chapter, the unexpected component of the risk factor was extracted from the rate of change in the risk factor.

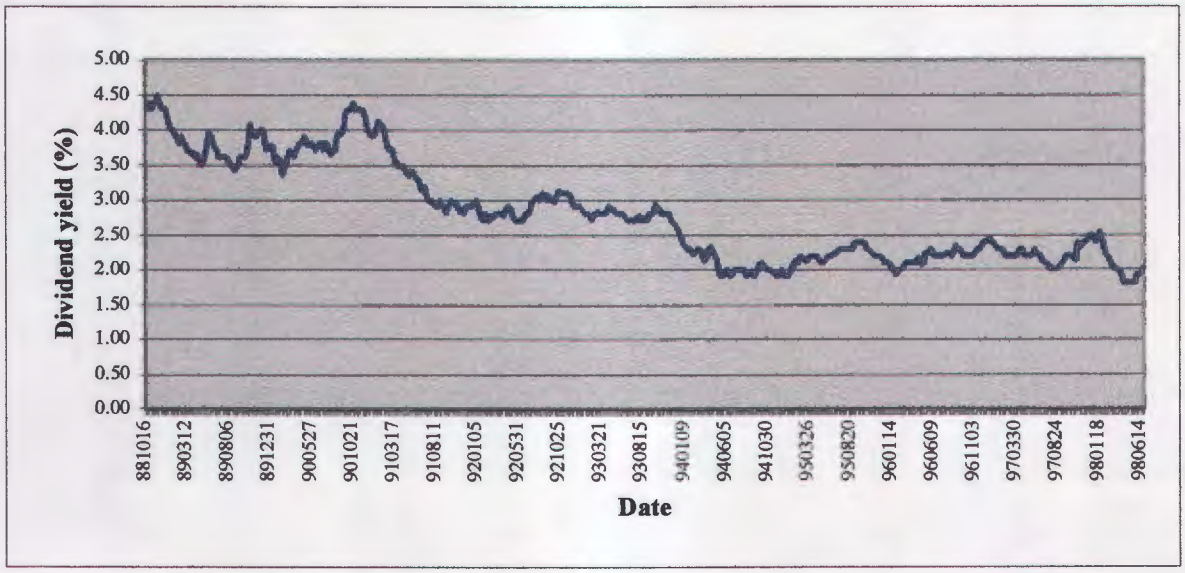
3.1.3.5 The rate of change in dividends

Dividends influence the expected cash flow accruing to shareholders of assets i at time t in equation 2.2, which gives the basic share valuation. This formula shows the price of a share to be equal to the net present value of all expected cash flows accruing to the shareholder by virtue of his or her ownership of this asset. Therefore the inclusion of dividends as a risk factor is justified because this has a direct influence on share returns.

Graph 3.12 shows a plot of the dividend yield for the financial and industrial sectors from 16 October1988 to 21 June 1998.

GRAPH 3.12

Dividend yield for the financial and industrial sectors of the JSE vs time from 16/10/1988 to 21/06/1998



As can be seen above, the dividend yield has declined steadily since the liberalisation of foreign exchange laws after the national elections in April 1994. A possible reason for this is that because the industrial giants had been prevented by foreign exchange controls from investing abroad they had been buying into each other's companies for years. The result was a formidable tangle of cross holdings where the four biggest companies, namely Anglo American, Sanlam, Rembrandt and Old Mutual, controlled about three-quarters of the JSE by 1994. After the liberalisation of foreign exchange controls, instead of paying high dividends to their stock holders, public companies started investing overseas, especially in places like Mozambique (Appendix 1, May 1996) and West Africa (Appendix 1, May 1996).

Paseran and Timmerman (1995) included the dividend yield as a candidate risk factor in their multifactor asset pricing model. It was decided not to use the dividend yield as a risk factor but rather to use dividends instead. The reason for this is that the dividend yield is calculated as:

$$DY = (\text{dividends/financial and industrial index}) \times 100$$

The dividend yield (DY), by virtue of its having the financial and industrial index in its denominator, is highly correlated with the financial and industrial index and, since this index is the dependent variable in the regression equation (LFM), it is not suitable.

This problem was overcome by using the dividends as the risk factor. The dividend was calculated by multiplying the dividend yield by the financial and industrial index.

The rate of change of dividends was calculated as follows:

$$PIFDIV_t = (IFDIV_t - IFDIV_{t-1})/IFDIV_{t-1}$$

where: $IFDIV_t$ = the dividends of the financial and industrial sector at time t

$IFDIV_{t-1}$ = the dividends of the financial and industrial sector at time t-1

Again, for reasons given in the previous chapter, the unexpected component of the risk factor was extracted from the rate of change in the risk factor.

3.1.3.6 The residual market risk factor

The residual market factor represents that variation in the market that is unexplained by the prespecified macroeconomic variables. The reason for including this variable in this study is that it is essential if we are to undertake an ITNLSUR analysis at a later stage (McElroy & Burmeister 1988:33).

Although the factor is unobservable, it can be estimated by f_k as shown below. The returns on a market proxy portfolio ($w_1, \ldots w_N$) are given by:

$$r_{mt} = \lambda_{ot} + \sum_{j=1}^{J} b_{mj}\lambda_j + b_{mK}\lambda_K + \sum_{j=1}^{J} b_{mj}f_{jt} + b_{mK}f_{Kt} + \varepsilon_{mt}$$

where:

$$b_{mj} = \sum_{i=1}^{N} w_i b_{ij}$$

$$b_{mk} = \sum_{i=1}^{N} w_i b_{ik}$$

$$\varepsilon_{mt} = \sum_{i=1}^{N} w_i \varepsilon_{it}$$

Assuming that f_{Kt} can be normalised, so that $b_{mk} = 1$ and setting ε_{mt}, the asset-specific risk in the market portfolio equal to zero (because of diversification), the model can be restated as:

$$r_{mt} = \lambda_{ot} + \sum_{j=1}^{J} b_{mj}\lambda_j + \lambda_K + \sum_{j=1}^{J} b_{mj}f_{jt} + f_{Ktt}$$

Furthermore, λ_m can be defined as:

$$\lambda_m = \sum_{j=1}^{J} b_{mj}\lambda_j + \lambda_K$$

so that the equation can be reduced to:

$$r_{mt} = \lambda_{ot} + \lambda_m + \sum_{j=1}^{J} b_{mj} f_{jt} + f_{Kt}$$

where λ_m denotes the excess expected return on the market (ie in excess of the risk-free rate). Of the variables in this equation, r_{mt}, λ_{ot} and f_{jt} are measured and input into the model and λ_m, b_{mj} can be estimated using ordinary least squares regression techniques.

An estimate for f_{Kt} can then be obtained from the resulting OLS error term of the model, and can thus be treated as an estimate of an unobserved residual market factor that can be included in the APT model.

This section draws on Reese (1993).

3.1.4 Extracting the unexpected component of risk factors

In accordance with the arbitrage price theory (ch 2, sec 2.3), risk factors must be treated in order to calculate their unexpected movement.

Van Rensburg (1995:54) states the following:

> The macroeconomic variables selected in this study are, or are directly derived from, market determined "prices". Assuming a reasonable degree of efficiency on the NYSE, the gold market and the South African bond market, the magnitudes of these variables are themselves the embodiments of expectations and, hence, not amenable to prediction. Expected values of these variables may be estimated by focusing on the returns on each of the financial assets incorporated in the derivation of the factors. As all of the variables are composed of financial assets, asset pricing theories such as the CAPM can be utilised to estimate expected returns. This study however adopts a simpler approach: It is not unreasonable to argue that the average monthly realised return over the sample period approximates the average monthly expected return. This could be attributed to the notion that rational investors' expectations are unbiased i.e. they do not consistently over or underestimate returns. In this case, averaging realised returns over an extended period would diversify away the effect of their random estimation errors and the figure arrived at would closely approximate average expected returns measured over the same time period. Thus, an initial estimate of the factor values are obtained by subtracting the mean value of the macrovariables from their realised values in each period.

> In addition, unexpected movements in a variable should not be able to be predicted from its past values. Thus, time-series modelling is utilised to forecast values of the above initial factor estimates and deviations from this forecast are taken to be unexpected. This step also aids in the correction of the deficiencies of the first step. In essence, using time series modeling, the macro-economic series were detrended in order to obtain a measure of their unexpected movements. The factor estimates derived in this manner should be void of auto-correlation. This was checked by viewing auto-correlation functions and Q statistics.

Priestley (1996:870) expresses agreement in the following passage:

> A condition required of the unanticipated components, however, is that they should be mean-zero, serially uncorrelated white-noise processes. Accordingly, any expectations process we specify must, at least, provide unanticipated components that satisfy these properties.

However, he goes on to say the following:

> The alternative methodology for generating unexpected components we specify, based upon the Kalman filter, does meet the basic requirements of providing, first, unexpected components which are innovations and, second, an expectations generating process which does avoid the possibility of agents making systematic forecast errors.

However, in order to compare our results with those produced by Van Rensburg (1996) and since the results of the out-of-sample analysis indicate that there is not much difference between the mean-squared errors from the models using the Kalman filter and the models using the autoregressive corrected factors (Priestley 1996:888), it was decided to use the autoregressive corrected factors in combination with the "rate of change" technique.

This decision is not unreasonable because it is consistent with that used by Clare et al (1997:649), which they describe as follows:

> In order to generate the shocks from the underlying macro-economic variables we began by estimating auto-regressive models up to order 12 for each of the variables. After simplifying these models according to mis-specification tests we collected the residuals from these models and used these residuals as the shock in each of the underlying macro-economic factors. ... Since the generated shocks are residuals from an OLS regression, they are all mean zero, as required by the APT; in addition they are all serially uncorrelated.

The unexpected movements in the factors were extracted as follows:

(1) *Calculating the rate of change.* The rate of change of each risk factor was calculated as this removes the inflationary effect on factors which have monetary measures such as the gold price. The net effect of this is the elimination of nonstationarity in the data.

(2) *Removal of autocorrelation.* As Kim and Sall (1993:187) explain:

> Ordinary regression analysis is based on several statistical assumptions. One key assumption is that the errors are independent of each other. However, with time series data, the ordinary regression residuals usually are correlated over time. It is not desirable to use ordinary regression analysis for time series data since the assumptions on which the classical linear regression model is based will usually be violated.
>
> Violation of the independent errors assumption has three important consequences for ordinary regression. Firstly, statistical tests of the significance of the parameters and the confidence limits for the predicted values are not correct. Secondly, the estimates of the regression coefficients are not as efficient as they would be if the autocorrelation were taken into account. Thirdly, since the ordinary regression residuals are not independent, they contain information that can be used to improve the prediction of future values.
>
> The AUTOREG procedure solves this problem by augmenting the regression model with an autoregressive model for the random error, thereby accounting for the autocorrelation of the errors. Instead of the usual regression model, the following auto-regressive error model is used:

$$y_t = x'_t\beta + v_t$$

$$v_t = -\phi_1 v_{t-1} - \phi_2 v_{t-2} - \ldots - \phi_m v_{t-m} + \varepsilon_t$$

$$\varepsilon_t \sim IN(0,\sigma^2)$$

The notation $\varepsilon_t \sim IN(0,\sigma^2)$ indicates that each ε_t is normally and independently distributed with mean 0 and variance σ^2.

By simultaneously estimating the regression co-efficients β and the auto-regressive error model parameters ϕ_I, the AUTOREG procedure corrects the regression estimates for autocorrelation. Thus, this kind of regression analysis is often called *auto-regressive error correction or serial correlation correction...*
The R= ... option specifies output variable for the ... residual, computed as the actual value minus the predicted value.

In other words, where autocorrelation is detected, the component of the factor which can be predicted because of this autocorrelation is removed by extracting the residuals of autoregressive time-series models designed to forecast future values of the factor.

Using the AUTOREG procedure and MODEL procedure SAS commands in the ETS submodule of the SAS computer software package, a simultaneous test for autoregression on each risk factor for up to 12 time lags was performed, and where it was detected, it was removed.

(3) *Bringing the factor mean to zero.* Following Burmeister and Wall (1986), a constant is added to the risk factor(s) to ensure that the mean is zero. As Van Rensburg (1996:106) explains:

> This manipulation is justified by the assumption that the average expected monthly change in the underlying macrovariable, is equal to its average realised monthly change over the period of the same. This assumption conforms to the notion of rational expectations, that rational investors will not consistently over- or underestimate returns over a sustained period of time and is equivalent to assuming that the long-term trend in the underlying macrovariable is expected.

The necessity of undertaking this step arises when a risk factor is not treated to correct for autoregression. The reason is that the residuals from step 2 are residuals from an OLS regression and hence are all mean zero (Clare et al 1997:649). Since all the risk factors were treated for autoregression, this step was redundant.

3.2 SHARE SELECTION

A share selection technique similar to that utilised by Reese (1993) was used in this study. The following criteria were used to select the share sample:

(1) The shares must be listed on the JSE for the entire duration of the study.

(2) The shares should be frequently traded so that the market price at a particular date could be assumed to be an accurate measure of the market's assessment of the worth of the share.

(3) The shares should represent a high percentage of the market capitalisation of the JSE, but should also include a mix of large and small firms, given the evidence in American studies that small firms appear to earn higher returns than their larger counterparts.

(4) Where possible, the sample should exclude shares which are not active or do not operate (eg the companies known as "cash shells" on the JSE) and also those which are the top company in a group pyramid structure (and as such are purely investment companies of other companies in the group). The inclusion of these shares would effectively be duplicating a share already in the sample and would thus be of limited use.

These being the selection criteria, it seemed logical to consider the shares chosen as the components of a market index as a useful guide.

The JSE was notorious for the low volume of shares traded on the market - a phenomenon known as "thin trading". Before the recent introduction of the computer on-line trading system (JET) the annual turnover was only 6 percent of the total market capitalisation. This has since improved to 30 percent, but it is still well below the turnover percentages of 65 percent for the NYSE.

The infrequency of trading means that the share price is not necessarily a good indicator of the market's assessment of the true worth of the share. Thin trading is problematic for any tests using JSE share prices. Thinly traded shares can lead to results that are less significant than those for well-traded shares. Barr and Bradfield (1988) reported that thin trading has an impact on both share prices and market indices. Another problem is that when thinly traded shares are used in a regression, the error term is heteroscedastic. This problem was dealt with as follows:

The weekly trading volumes of the selected shares were examined. If a share failed to trade in 20 weeks out of the 10 years (two weeks per year), then the share was excluded from the sample. A similar approach had been previously used by Page (1986), in his study of the APT on the JSE. Page eliminated all shares which did not trade for more than two consecutive weeks. These methods do not attempt to adjust for the effects of thin trading on the share prices or the market indices (as performed by Dimson 1979), but simply sidestep the problem by choosing shares that are known to be well traded. Hence some of the problems of thin trading should be obviated.

Reese (1993:45) deals with the problem of market coverage as follows:

> The share sample should cover a sufficiently large percentage of market capitalisation of the JSE (share price multiplied by the number of shares in issue). In addition, no one sector or industry should be dominant in relation to the others. The sample should represent the JSE fairly accurately in terms of its nature and composition. If one sector dominates the sample, then a factor specific to that sector could be indicated as a priced factor, when it is essentially sector-specific risk and so could be eliminated by portfolio diversification. For example, if there was a high percentage of tin-mining shares in the sample, then the results might indicate that the world price of tin was a priced factor. Market-wide, the tin-price is unlikely to affect all shares and so cannot be considered to be a systematic risk factor in the APT.

In his selection of shares to test the APTM on the JSE, Slaney (1995:41) agrees with Reese's (1993) methodology with one exception:

> While Reese (1993), excluded "cash shells" and other nonoperational firms (such as the ultimate holding company in a pyramid structure), these companies were not excluded from this study for three reasons:
>
> (1) The subsidiaries of such companies were often afflicted by thin trading and thus excluded from the sample. Hence there was unlikely to be excessive double counting. Also, the inclusion of the holding company would allow for the inclusion of the prospects of these subsidiaries (although indirectly) which would otherwise not have been possible.
> (2) The holding companies may be affected by the macroeconomic factors in different ways to their subsidiaries if they are merely cash shells. To exclude them would lead to the exclusion of companies with these potentially separate effects. They were listed companies in their own right and the models used should also fit their return-risk profiles.
> (3) Investors themselves do not differentiate between these companies and operational companies. They are concerned only with the return they expect to earn and the risk they bear, not the operations of the company (Markowitz:1952).

Following the procedure outlined above, the components of the financial and industrial sector index (FINDI30) were examined. However, only those shares which remained as constituents of this index over the entire period were included. This narrowed the sample of shares from 30 to 15. A further 43 shares were chosen. They met the criteria of continuous listing and active trading. Of these, 28 shares had been chosen by Slaney (1995) for his share sample. Nine shares were chosen in order to strengthen the banking and insurance sectors. (Banks were underrepresented since many only listed from 1987 onwards after a change in legislation made it easier for banks to become public companies.) Five shares were chosen to strengthen an assortment of other sectors.

The final selection of 57 shares is shown in Appendix 2.

As in the case of Page (1986), Barr (1990), Reese (1993) and Van Rensburg (1996), when calculating the ratio of change on each of the shares chosen, because of the nonavailability of data, dividends were excluded from the analysis.

The dependent variable in our linear factor model is the financial and industrial index. To facilitate compatibility with the ITSUR methodology, the excess return realisation on the financial and industrial index was used. This was calculated by subtracting the risk-free rate from the financial and industrial rate. The three-month treasury bill tender rate was used as a proxy for the risk-free rate. Slaney (1995) provides arguably the most comprehensive explanation for the use of this instrument in the South African context:

> The risk free Rate (R_f) is the return on an asset which has zero variance (ie the theoretical R_f is constant across all periods), and zero covariance with the returns on all risky assets ... In practice, there is no asset for which returns are constant, but to empirically test either model, a proxy is needed that is as free of risk as possible. The most risk-free asset available is usually taken to be the return on Government Bonds or Treasury Bills (T-Bills). The reason for this is that the default risk (as opposed to the interest rate risk), is zero for two reasons:
>
> 1. The government has a large incentive to ensure it does not default on its debts. Were it to do so, it would not be able to raise further debt in the future, hence crippling the economy.
> 2. Were the government ever to be short of cash to meet its debt commitments, it could raise taxes or increase the money supply to generate such cash. The only time this would not be possible would be where the economy of the country had already collapsed. In any financial model, an implicit assumption must be, that the country as a whole is a "going concern".
>
> Government instruments are, however, still subject to interest rate risk (ie. the risk that the value of the instrument will change, with a change in the market rate of interest) and are thus not completely risk free as required by the theory. The risk-free rate will thus change with the market rate of interest. Thus, when the T-Bill rate is used, R_f should more accurately be written as R_{ft}, ie. the risk-free rate in period t.
>
> Merton (1973), states that risk-free assets need only be riskless for instants of time, provided that continuous trading is allowed. This does not, however, require further assumptions and theoretical grounding. Scholes (1971), quoted in Merton (1973, 883), found the correlation coefficient between the market portfolio and a portfolio of bonds to be near zero, meaning that empirically, the required zero co-variance between R_f and all risky asset returns holds approximately. Thus, the return on Government Bonds is an acceptable approximation of R_f.
>
> The 90 day T-Bill rate was used as the proxy for the risk-free rate in this study. This rate displayed a low level of correlation with returns on all the market indices employed. It had a correlation co-efficient of 0.014 with the ALSI, -0.073 with the Gold Index and 0.044 with the industrial index. These correlation coefficients are considered sufficiently low for the 90-day T-Bill rate to be considered free of systematic risk, irrespective of the market proxy used.

However, government instruments offering different maturities exist, typically split between short term T-Bills with a maturity of up to three months, and long term government bonds. The typical proxy for the risk-free asset is the short term T-Bill, but there is nothing in the theory precluding the use of a longer term Government Bond.

Pringle and Harris (1984), quoted in Firer (1993, 26), suggested that the maturity of the risk-free asset be matched to the maturity of the investor's intended holding period. Ross, Westerfield and Jaffe (1993), Gilbertson (1979) and Brealey and Myers (1990), all quoted in Firer (1993, 26-28), as well as Firer himself, all suggested the use of the three month T-Bill rate as a proxy for R_f. Harrington (1987), stated that the zero variance property of the T-Bill only holds for short periods of time and thus advocated the use of a T-Bill with as short a maturity as possible, while still trying to match its maturity with that of the investment.
In South African studies several proxies have been used for R_f, including a 360 day T-Bill, a 90 day T-Bill and the 12 month fixed deposit rate (Firer, 1993). The 90 day T-Bill rate was the shortest government rate available in South Africa for which data was quoted on the I-Net database. It is also the government instrument with a maturity as close to the implicit holding period of one month as possible.

The excess return on the financial and industrial index was calculated as follows:

$$R_t = (FIIND_t - FIIND_{t-1}/FIIND_{t-1}) - TBT3_t \qquad (3.1)$$

where: $FIIND_t$ = F & I index at time t

$FIIND_{t-1}$ = F & I index at time t-1

$TBT3_t$ = treasury bill 3-month tender rate at time t

Finally, to test if the 57 shares chosen could truly proxy for the financial and industrial index, an index was constructed representing the 57 shares where each share was weighted in the index according to its market capitalisation (this method is consistent with that used in the construction of the F & I index). Although information necessary in calculating the index for the whole period was not available on the I-NET, using available information it was established that during the period November 1994 to March 1998 the Pearson's correlation coefficient between this index and the financial and industrial index was .94033.

3.3 SELECTION OF INSTRUMENTS

Following the arguments presented by Burmeister and McElroy (1998), allowance has to be made for the possibility that the market portfolio is an endogenous variable. This requires that a market portfolio, defined here as the excess returns on the financial and industrial index, be included as a risk factor to replace the residual market factor of the ITNLSUR approach. Simultaneously, an equation defining the market portfolio as the dependent variable to the nine risk factors has to be added to the other 57 share returns that have to be simultaneously solved.

Since the market portfolio is an exogenous variable in all equations except the 58th and an endogenous variable in the 58th equation, using the ordinary least squares (OLS) estimation method to estimate these equations produces biased estimates.

Erdman, Little and Sall (1993:553) suggest that one solution to this problem is to replace this factor on the right-hand side of the equations (exogenous variable) with predicted values. A method of estimating the predicted values is known as instrumental regression. An instrumental regression is a regression of the dependent regressors on a set of instrumental variables which may be any independent variables useful for predicting the dependent regressors. This method is known as two-stage least square or 2SLS. Furthermore, if as in this case the equation system is simultaneous, it is possible to combine the 2SLS and seemingly unrelated regression (SUR) methods to take into account both dependent regressors and cross-equation correlation of the errors. This method is called the three-stage least squares (3SLS).

The following guidelines on choosing instrumental variables are provided by Erdman et al (1993:591):

> There is no standard method for choosing instruments for nonlinear regression. Few econometric textbooks discuss the selection of instruments for nonlinear models... The purpose of the instrumental projection is to purge the regressors of their correlation with the residual. For non-linear systems, the regressors are the partials of the residuals with respect to the parameters.

Possible instrumental variables include:
1. Any variable in the model that is independent of the errors.
2. Lags of variables in the system.
3. Derivatives with respect to the parameters, if the derivatives are independent of the errors.
4. Low degree polynomials in the exogenous variables.
5. Variables from the data set or functions of variables from the data set.

Selected instruments must not:
1. Depend on any variable endogenous with respect to the equations estimated.
2. Depend on any of the parameters estimated.
3. Be lags of endogenous variables if there is serial correlation of the errors.

If the preceding rules are satisfied and there are enough observations to support the number of instruments used, the results should be consistent and the efficiency loss held to a minimum.

At least as many instruments as the maximum number of parameters in any equation are needed, otherwise some of the parameters cannot be estimated. Note that *number of instruments* means linearly independent instruments. If you add an instrument that is a linear combination of other instruments, it has no effect and does not increase the effective number of instruments.

However, too many instruments can be used. To obtain the benefit of instrumental variables, more observations than instruments are needed. Thus, there is a trade-off; the instrumental variables technique completely eliminates the simultaneous equation bias only in large samples. In finite samples, the larger the excess of observations over instruments, the more the bias is reduced. Adding more instruments can improve the efficiency, but after some point, efficiency declines as the excess of observations over instruments becomes smaller and the bias grows.

Following the suggestions of Amemiya (1977) and consistent with Priestley (1996), the researcher specified as instruments current and squared values of the exogenous variables (nine risk factors) and instrumented for the market portfolio the returns on the mining financial index, squared values of the returns on this index and the fitted values and squared fitted values from a regression of the return on the market portfolio on the nine factors.

The returns on the mining financial index were chosen as an instrument for the market portfolio because these returns should not have any correlation with the error in the market (F & I index) portfolio equation.

3.4 DATA SOURCE

The share price data and the financial and economic data were obtained from I-NET. This data base is maintained and updated on a daily basis for share splits, consolidations and de-listings.

- The monthly data used cover the period March 1985 to May 1998.
- The weekly data used cover the period 14 August 1998 to 28 June 1998.
- The daily data used cover the period 8 August 1988 to 15 July 1998.

CHAPTER 4
MODELS TO TEST THE HYPOTHESES

4.1 THE RECURSIVE LINEAR FACTOR MODEL

The conventional way of testing the APTM (Van Rensburg 1996) is to find the most significant risk factors in the LFM and then to confirm whether or not they are priced in the APTM.

To establish which risk factors are priced and when they are priced in the LFM applicable on the JSE (financial and industrial sector), during the period 1 April 1988 to 31 March 1998, the researcher used the model developed by Paseran and Timmerman (1995).

This is a recursive model, which kept a running score of which risk factors entered or left the LFM month by month, from 1 April 1988 to 31 March 1998.

The base set of nine risk factors was established in the previous chapter (sec 3.1). At each point in time, the optimal model specification was searched for and a note made of which risk factors were priced.

Suppose that, at each point in time, t, we calculate from a base set of k factors, all possible excess return regressions. Standard statistical criteria for model selection are applied to the set of regression models spanned by all possible permutations of the k factors/regressors $x_1, x_2, \ldots, x_k$ in the base set. This gives a total of 2^k different models, each of which is uniquely identified by a number, i, between 1 and 2^k. Consider a k x 1 selection vector, v_i, composed of ones and zeros, where a one in its jth element means that the jth regressor is included in the model, whereas a zero in its jth element means that this regressor is excluded from the model. The model i (denoted by M_i), can be represented by the k-digit string of zeros and ones corresponding to the binary code of its number. Denoting the number of regressors included in model M_i by k_i, then $k_i = e' v_i$, where e is a k x 1 vector of ones.

Suppose that ρ_t, the excess return at time t, is forecast by means of linear regressions

$$M_i : \rho_{\tau+1} = \beta'_i X_{\tau,i} + \varepsilon_{\tau+1,i} \qquad \tau = 1, 2, \ldots, t-1. \tag{4.1}$$

Where $X_{\tau,i}$ is a $(k_i + 1) \times 1$ vector of regressors under model M_i, obtained as a subset of the base set of regressors, X_τ, chosen at the beginning of the experiments, plus a vector of ones for the intercept term. Conditional on model M_i and given the observations $\rho_{\tau+1}$, $X_{\tau,i}$, $\tau = 1, 2, \ldots, t-1$ (with $t \geq k+2$), parameters of model M_i can be estimated by the ordinary least squares (OLS) method. Denoting these estimates by $\hat{\beta}_{t,i}$ we have

$$\hat{\beta}_{t,i} = \left(\sum_{\tau=0}^{t-1} X_{\tau,i} X'_{\tau,i}\right)^{-1} \sum_{\tau=0}^{t-1} X_{\tau,i}\rho_{\tau+1}, \qquad \text{for} \quad t = k+2, \kappa+3, \ldots, T, \quad \text{and} \quad i = 1, \ldots, 2^k$$

The OLS estimates are fairly simple to compute and in view of the Gauss-Markov theorem, are reasonably robust, even in the presence of non-normal errors in the excess return equation.

The particular choice of $X_{\tau,i}$ to be used in the forecasting of $\rho_{\tau+1}$ will be based on a number of statistical model selection criteria suggested in the literature. The selection criteria to be used will be the $\bar{R}^2$ and Akaike's information criterion (AIC) (Akaike 1973). These criteria are likelihood-based and assign different weights to the "parsimony" and "fit" of the models. The "fit" is measured by the maximised value of the log-likelihood function ($\hat{LL}$), and the "parsimony" by the number of freely estimated coefficients. At time t, and under model M_i, we have

$$\hat{LL}_{t,i} = \frac{-t}{2} \{ 1 + \log(2\pi\hat{\sigma}^2_{\tau,i}) \}$$

where:

$$\hat{\sigma}^2_{t,i} = \sum_{\tau=0}^{t-1} (\rho_{\tau+1} - X'_{t,i}\hat{\beta}_{t,i})^2/t$$

The Akaike model selection criterion can be written as:

$$AIC_{t,i} = \hat{LL}_{t,i} - (k_i + 1)$$

The $\bar{R}^2$ criterion, originally suggested by Theil (1958) as a criterion for selecting regressors in a linear regression model, is given by:

$$\bar{R}^2_{t,i} = 1 - \frac{\tilde{\sigma}^2_{t,i}}{S^2_{\rho,t}}$$

where:

$\tilde{\sigma}^2_{t,i}$ is the unbiased estimator of σ^2 given by:

$$\tilde{\sigma}^2_{t,i} = \sum_{\tau=0}^{t-1} (\rho_{\tau+1} - X'_{\tau,i}\hat{\beta}_{t,i})^2/(t-k_i - 1),$$

$S^2_{\rho,t} = \sum_{\tau=1}^{t} (\rho_\tau - \bar{\rho}_t)^2/(t - 1)$ is the sample variance for the first t observations on ρ,

and $\bar{\rho}_t = t^{-1}\sum_{\tau=1}^{t} \rho_\tau$.

The $\bar{R}^2$ criterion can also be written explicitly as a trade-off between fit and parsimony:

$$TC_{t,i} = \hat{LL}_{t,i} - \tfrac{1}{2}\log\left(\frac{t}{t - k_i - 1}\right).$$

It is easy to show that, in the context of linear regression models, the $\bar{R}^2_{t,i}$ and the $TC_{t,i}$ criteria are equivalent, in the sense that they select the same model.

In the case of multiple regression, the $\bar{R}^2$ criterion must be adjusted for the presence of additional independent variables if a valid comparison is to be made between the single and multiple factor models. This adjustment is given by:

$$\text{Adj } R^2 = 1 - \frac{n-1}{n-k} (\bar{R}^2)$$

where: n = number of data points in the sample

k = number of risk factors

In each case, the model selection criteria described before will be applied to linear regression models, using the excess returns on the JSE financial and industrial index as the dependent variable, and subsets of the base set of regressors as the independent variables. For our set of nine regressors, this means comparing $2^9 = 512$ models at each point in time, and over the period 1 April 1988 to 31 March 1998, this gives a total of 61 440 (512 x 120) regressions to be computed.

To summarise, the recursive model specification proceeds as follows: in April 1988 the values of the selection criteria are computed for each of the 2^k (512) possible combinations of regressors from the base set, using monthly data over the period, May 1985 to April 1988. An intercept term is included in all the regressions. The model that maximises the discriminant function of a given model selection criterion is chosen, and the parameter values that are estimated, noted. To calculate the best regression for the monthly excess returns for May 1988, the procedure is repeated for all the 2^k models, using monthly data over the period, June 1985 to May 1988.

Under normal circumstances, the results from this section, namely, the 120 best subset LFMs would be tested, by placing the APT restrictions to see which factors are statistically significant. For practical reasons explained in chapter 5 (sec 5.1.2), weekly data, instead of monthly data, had to be used. This required the recalculation of the recursive LFM using weekly data. The lack of some weekly data from the I-Net necessitated the narrowing of the

period under consideration from 1 April 1988 to 31 March 1998 to 20 October1991 to 21 June 1998. This produced 87 four-week periods during which the best subset LFM had to be tested.

One feature of the best subset LFM is that not all risk factors are included in it. Thus risk factors were not tested period for period to see if they were priced and we have not obtained a picture of their performance over the period under consideration.

Therefore, the only way to evaluate the importance of a risk factor in terms of how often it is priced and when it is priced was to divide the 87 periods into subperiods and then to compare their performance from subperiod to subperiod.

The decision on how many subperiods to use was restricted by the fact that if the subperiods were to be tested adequately they had to be long enough to make it possible to include each risk factor in sufficient LFMs.

For reasons explained in chapter 5 (sec 5.1.2), the 87 time periods, from 20 October1991 to 21 June 1997, were subdivided into three equal subperiods of 29 four-week periods.

From the analysis of these three subperiods, it was be possible to evaluate which risk factors become priced in the APTM over the period under consideration.

It was then possible for the researcher to examine any change in the specification of the APTM and, depending on the timing of this change, to relate it to any significant political and/or economic event or events.

This approach of working backwards in solving the research problem was arrived at after considerable time had been spent evaluating the alternatives.

One can adopt two obvious approaches to solving the research problem of determining how political and economic events change the specification of the APTM.

Approach 1

(1) Arrive at the specification of the best subset LFMs for the 120 monthly periods over the period under consideration.

(2) Test the risk factors in each of the 120 LFMs to see which are priced in the APTM.

(3) If it is assumed - as previous research in South Africa has implied - that a priced risk factor in the LFM will be priced in the APTM, we would be able to predict the specification of the APTM by looking at the betas of the risk factors in the LFM.

(4) It would then be possible to correlate the specification of the APTM directly with a plot of the standardised beta of the risk factors and, subsequently, with political and economic events. Our rationale will be, that since a political or economic event impacts on a particular risk factor, the risk sensitivity (beta) of this risk factor would change, and provided the impact was significant, it would make the change large enough to be priced in the LFM, and subsequently in the APTM. Appendix 9 shows a plot of each factor as described above.

Approach 2

Another approach would be to plot the square of the standardised beta of each risk factor in the LFM against the adjusted R^2 statistic. Appendix 7 shows a plot of each risk factor as described above. This plot would give us the unique contribution of each risk factor towards the explanatory power of the LFM.

Depending on the behaviour, that is, when exactly the unique contribution increases, it would be possible to match this against a political or economic event proxied by that risk factor. Again, the rationale will be that as a political or economic event impacts on a particular risk factor the beta of this factor will change. The square of the beta, which indicates the unique contribution of this risk factor towards the total explanatory power of the model, would also change, indicating whether or not it is now significant. Being significant in the LFM would then imply that it was significant in the APTM.

Unfortunately none of these approaches was feasible for the following reason. As will be shown in chapter 6, there is no correlation between a risk factor being priced in the LFM and subsequently being priced in the APTM. Approaches 1 and 2 are therefore fundamentally flawed.

Since one cannot predict *a priori* which political and economic events will affect the APTM model, an approach where one works backwards towards finding a relationship between a political and economic event when detecting a change in specification of the APTM seemed to be reasonable.

This choice of research methodology is supported by the findings of Beck (1995), who found that share prices were relatively insensitive to major political and economic events and concluded that these events appear to influence the general health of the economy and subsequently the share prices over a longer period of time.

4.2 THE ARBITRAGE PRICING THEORY AS A RESTRICTED NONLINEAR MULTIVARIATE REGRESSION MODEL

As noted by McElroy and Burmeister (1988:29), by regarding the APT as a multivariate nonlinear regression model, with across-equation restrictions, the highly developed least squares statistical machinery for such nonlinear systems can be accessed.

The two such "pieces of machinery" used in this thesis are the ITNLSUR and the NL3SLS techniques.

The two different approaches are fully explained over the next two sections, and the decision as to why we should use both is explained in chapter 4 (sec 4.2.3).

4.2.1 The iterated nonlinear seemingly unrelated regression (ITNLSUR) technique

The arbitrage pricing restrictions can be seen as being manifested in two ways. Firstly, the intercept of the linear factor model is constrained as follows for each asset i:

$$E(R_{it}) - R_{ft} = b_{i0} = \sum_{k=1}^{K} b_{ik}\lambda_k$$

Secondly, the values of the risk premia are constant across each equation in the system. In other words, all assets with the same sensitivity profiles will have the same expected returns. In order for this across-equation constraint to exist, the researcher used the system equation technique of a seemingly unrelated regression. Thus, the following system was estimated:

$$R_{it} - R_{ft} = \sum_{k=1}^{K} b_{ik}\lambda_k + \sum_{k=1}^{K} b_{ik}f_{kt} + \varepsilon_{it} \qquad (4.2)$$

for i = 1, ... n and t = 1, ... T.

where:

R_{it} = realised returns on asset i in time period t

R_{ft} = the risk-free rate of return at time t

b_{ik} = the sensitivity of asset i to factor k

λ_k = the risk premium associated with factor k

f_{kt} = the unexpected movement in factor k at time t

ε_{it} = the error term for asset i at time t

Equation 4.2 may be written in matrix notation as:

$$\rho_i = \sum_{k=1}^{K} (\lambda_k \iota_T + f_k) b_{ik} + \varepsilon_i$$

where:

$$\rho_i = (R_{i1} - R_{f1}, \ldots, R_{iT} - R_{iT})' \text{ for } i = 1, \ldots n$$

$$f_k = (f_{k1}, \ldots, f_{kT})' \text{ for } k = 1, \ldots K$$

$$\varepsilon_i = (\varepsilon_{i1}, \ldots, \varepsilon_{iT})' \text{ for } i = 1, \ldots n$$

and ι_T is a T dimensional column vector of ones.

This system may, in turn, be re-expressed as follows:

$$\rho_i = X(\lambda) b_i + \varepsilon_i$$

where:

$$\underset{T \times k}{X(\lambda)} = (\lambda' \otimes \iota_T) + F$$

$$\underset{k \times 1}{\lambda} = (\lambda_1, \ldots, \lambda_K)'$$

$$\underset{T \times k}{F} = (f_1, \ldots, f_K)$$

$$\underset{k \times 1}{b_i} = (b_{i1}, \ldots, b_{iK})' \text{ for } i = 1, \ldots n$$

and $\otimes$ denotes the Kronecker product.

Stacking the n equations yields:

$$\begin{bmatrix}\rho_1\\ \rho_2\\ \cdot\\ \rho_n\end{bmatrix} = \begin{bmatrix}\chi(\lambda) & 0 .. & \dots & 0\\ 0 & \chi(\lambda) & \dots & 0\\ \cdot & \cdot & \dots & \cdot\\ 0 & 0 & \dots & \chi(\lambda)\end{bmatrix} \begin{bmatrix}b_1\\ b_2\\ \cdot\\ b_n\end{bmatrix} + \begin{bmatrix}\varepsilon_1\\ \varepsilon_2\\ \cdot\\ \varepsilon_n\end{bmatrix}$$

which can also be expressed as :

$$\rho=[I_n \otimes \chi(\lambda)]b+\varepsilon$$

where :

$$\rho = (\rho_1, \dots, \rho_n)'$$
$$b = (b_1, \dots b_n)'$$
$$\varepsilon = (\varepsilon_1, \dots, \varepsilon_n)'$$

and $E(\varepsilon) = 0_{nT}$ and $E(\varepsilon\varepsilon') = [\Sigma \otimes I_T]$, where Σ is the n x n variance-covariance matrix of the contemporaneous residuals of assets i=1, n and j=1, ... n.

McElroy and Burmeister (1988:32) demonstrate that the APT model does fulfil the necessary condition for nonlinear seemingly unrelated regression (NLSUR) estimators to exist.

NLSUR estimators may be obtained by following three steps:

(1) Equation 4.2 is estimated via share-by-share OLS. This is the same procedure that is followed in the first step of the Fama and MacBeth (1973) "two-step" procedure. As a result, a vector of estimates $b_i = (b_{i0} + b_{i1} \dots + b_{ik})$ is obtained for each share i. The intercept term b_{i0} is equal to the cross-product sum:

$$\sum_{k=1}^{K} \lambda_k b_{ik}$$

Unlike in the two-step procedure, the output utilised is not b_I, but the residual vector from these regressions ε_I where:

$$\varepsilon_i = \rho_i - \sum_{k=1}^{K} b_{i0}\iota_T + f_k b_i$$

(2) The residual vector ε is used to obtain an estimate of Σ:

$$\Sigma = [T^{-1}\varepsilon_i\varepsilon_j]$$

(3) The estimated variance-covariance matrix is plugged in to the following quadratic form, Q:

$$Q(\lambda,b,\Sigma) = [\rho-(I_n\otimes\chi(\lambda)b]' [\Sigma^{-1}\otimes I_T] [\rho-(I_n\otimes\chi(\lambda)b] \quad (4.3)$$

Values for λ and b are chosen in order to minimise the value of this expression.

Equation 4.3 can be simplified as follows:

$$Q(\lambda,b,\Sigma) = \varepsilon'[\Sigma^{-1}\otimes I_T]\varepsilon \quad (4.4)$$

Thus, it can be seen that a weighted sum of squared errors is being minimised with respect to λ and b, subject to information on the estimate of the variance-covariance matrix Σ.

The above procedure may be repeated, with iteration occurring between the estimates of Σ and the parameters λ and b. Residuals from the most recent estimates of λ and b are used to update the estimate of Σ. This in turn updates the quadratic form Q, allowing revised estimates of λ and b. Iteration occurs until estimates of the covariance matrix, Σ, stabilise. This estimation technique is called an iterated nonlinear seemingly unrelated regression (ITNLSUR).

Being least squares estimators, the ITNLSUR estimators are also strongly consistent and asymptotically normal, even if the error distribution departs from normality. The robustness of the McElroy and Burmeister (1988) method to the non-normality of the error distribution is an important consideration in South Africa because of the apparent absence of normality in returns on the JSE (Klerck & du Toit 1986).

This section draws on Van Rensburg (1996), McElroy and Burmeister (1988) and Reese (1993).

4.2.2 The nonlinear three stage least squares (NL3SLS) technique

The multifactor APT model of security returns derived by Ross (1976) begins by specifying the following relationship:

$$R_t = E(R) + B_\lambda F_{kt} + u_t, \tag{4.5.a}$$

$$E(R) = \lambda_0 \iota_N + B_k \lambda_k, \tag{4.5.b}$$

which is equation 4.2 in matrix format.

Where R_t is an N vector of security returns, F_{kt} is a zero mean, k a vector of observations on the k pervasive risk factors at time t generated using either factor analysis, or observed macroeconomic variables: B_k is an Nxk matrix of sensitivities of security returns to the factors, u_t is an N vector of zero mean, idiosyncratic returns, E(R) is an N vector of expected returns, λ_0 is the return on the risk-free asset, ι_N is an N vector of ones and λ_k is a k vector of (constant) prices of risk associated with the k systematic risk factors. One of the assumptions made in this model is that the correlation between the factors, F, and idiosyncratic returns, u, is zero. The significance of this is that since idiosyncratic returns are uncorrelated with the pervasive factors, the covariance matrix of returns can be decomposed into:

$$\Sigma_R = \Sigma_F + \Sigma_U, \tag{4.6}$$

where Σ_F is the covariance matrix of the factors (representing systematic or pervasive risk) and Σ_U is the covariance matrix of idiosyncratic returns (representing idiosyncratic risk). It is the assumption about the form of Σ_U that determines whether the factor structure of returns is strict or approximate. Ross (1976), for example, assumes that Σ_U is a diagonal matrix which means that idiosyncratic returns are uncorrelated across assets, since the off-diagonal elements of the matrix are zero. In this case, returns are said to have a strict factor structure. This assumption about returns having a strict factor structure is made implicitly in many empirical studies of the APT. For example, factor analysis extracts factors from Σ_F under the assumption that Σ_U is diagonal (see, eg Roll & Ross 1980), while studies which use observed macroeconomic variables as the factors usually obtain estimates of the parameters from OLS regressions, which again assumes Σ_U to be diagonal.

As an alternative to returns following a strict factor structure, Chamberlain and Rothschild (1983) show that the APT still holds under the much weaker assumption that Σ_U is nondiagonal, such that idiosyncratic returns are correlated across assets, as long as the first k eigenvalues of Σ_R are unbounded - as the number of assets approaches infinity, while the k+1th eigenvalue is bounded, that is, the first k eigenvalues increase as the number of assets increases, while the k+1th eigenvalue of Σ_R is less than the largest eigenvalue of Σ_U. In this case, returns have an approximate k factor structure.

By substituting (4.5.b) into (4.5.a) and stacking the equations for the N securities, we get:

$$R - \lambda_0 = \{I_N \otimes [(\lambda' \otimes \iota_T) + F]\}B + u, \tag{4.7}$$

where R is an NT x 1 vector of security returns, λ is a kx1 vector of prices of risk, F is a Txk matrix of observations on the k factors, B is an Nkx1 vector of sensitivities, I_N is an NxN identity matrix and $\otimes$ is the Kronecker product operator.

If the system is not supplemented by an equation for the market portfolio, from which the equity market risk premium can be calculated, and the market portfolio is not included as a factor, then the NLSUR estimators for the APT model are those values of B and λ that solve the following problem:

$$\min_{\lambda,B} u'(\hat{\Sigma}_U^{-1} \otimes I_T)u, \tag{4.8}$$

where u is derived from 4.7, Σ_U^{-1} is the estimated residual (idiosyncratic return) covariance matrix from estimating 4.7 with $(\lambda' \otimes \iota_T)B$ replaced by a constant and I_T is a T x T identity matrix. This is the ITNLSUR approach and equation 4.8 is equivalent to equation 4.4.

The system can be extended in a straightforward fashion to include an equation for the market portfolio. However, if this is the case, the market portfolio must be treated as endogenous and the system estimated by nonlinear three-stage least squares (NL3SLS). In this case, the minimisation problem becomes

$$\min_{\lambda,B} u'(\hat{\Sigma}_U^{-1} \otimes Z(Z'Z)^{-1}Z')u, \tag{4.9}$$

where Z is a matrix of instrumental variables. An important point to note here is that Σ may be nondiagonal, thereby allowing for idiosyncratic returns to be contemporaneously cross-correlated or it can be restricted to being diagonal, imposing a strict factor structure. The parameter standard errors are given by Ω^{-1} ,where:

$$\Omega = G'(\hat{\Sigma}_U^{-1} \otimes Z(Z'Z)^{-1}Z')G, \tag{4.10}$$

where G is the matrix of partial derivatives of u with respect to the parameters. From (4.9) and (4.10), it can be seen that the specification of Σ_U may make a significant difference to reported results, in terms of both estimated prices of risk and their significance.

This section draws on Garrett and Priestley (1997).

4.2.3 Conclusion

Research published in South Africa in which the APTM was tested has exclusively used the ITNLSUR technique (Reese 1993; Van Rensburg 1996).

Clare, Priestly and Thomas (1997) have shown that the choice of the 3NLS over the ITNLSUR technique is critical in determining whether or not the results are valid when testing the APTM on the London Stock Exchange.

Since the 3NLS has never been used in South Africa, and there is a possibility that it may be more suitable than the ITNLSUR technique, it was considered essential to use both techniques.

CHAPTER 5
RESULTS

5.1 THE RECURSIVE LINEAR FACTOR MODEL

Although the LFM, as explained previously, is not an asset pricing model, the aim of this model is to identify which risk factors maximise certain selection criteria (Adjusted R^2 and/or Akaike's information criterion) and then to test them in the "full APTM" to see if they are priced. Although they show sensitivity to asset returns, they should in fact be statistically significant. A similar approach was used by Berry, Burmeister and McElroy (1988), as well as by Van Rensburg (1996).

Although the recursive linear factor model looks complicated, the selection of the best LFM was essentially determined using OLS regressions. This process was repeated month by month over a period of 120 months, using a 36-month (three year) data base. The data base was moved along the 120-month testing period, month by month, adding one month (current month) and dropping one month (oldest month).

Both the research papers quoted above used monthly data in their analysis of the APTM.

To maintain consistency with their approach, this thesis initially used monthly data for the recursive LFM.

However, when the time came to test the risk factors imposing the APT restrictions (consistent with asset pricing models), a problem was encountered. Since testing the APTM involves the joint estimation of factor sensitivities (βs), as well as risk premia (λs) in nonlinear regressions, there is a possibility that the results may be affected by small sample problems.

On this subject, McElroy and Burmeister (1988) point out that the estimators λ and β will exist as long as $NT>Nk+k$, where N is the number of equations, T is the number of observations and k is the number of prices of risk to be estimated.

Also, it is essential that there should be enough observations because if N>T, then the variance-covariance matrix of the residuals becomes singular and results become meaningless.

Garret and Priestley (1997) give some guidelines on the number of degrees of freedom per equation necessary to avoid the small sample size problem. The number of degrees of freedom available for the system is obtained from:

$$TDF = ((NT) - (Nk+k)) - (N+N(N-1)/_2) \quad (5.1)$$

where:

TDF is the total number of degrees of freedom available in the system.

The number of degrees of freedom per equation is:

$$TDFE = TDF/N \quad (5.2)$$

where:

TDFE is the total number of degrees of freedom per equation.

Garret and Priestley (1997) use 164 observations (T), 70 equations (N) and 10 risk factors (k) and calculate the number of degrees of freedom per equation as 118, which they regard as adequate. Van Rensburg (1996) uses 120 observations, 72 equations (N) and five risk factors (k), which provides 78 degrees of freedom per equation.

Going back to our problem, if monthly data had been used to test the APTM in this thesis, the data base of 36 months would not have been sufficiently large, as there were 57 equations to be estimated in the ITNLSUR technique[1], that is N=57 and T=36. Because N>T this would have caused the covariance matrix of the residuals, which is the first step in the ITNLSUR approach, to become singular.

[1] 58 equations when the NL3SLS technique is used.

This problem was overcome by deciding to use weekly instead of monthly observations and in this way transform the database from 36 to 156 observations.

Using the new set of data (N=57, T=156, K=6.8[2]) and substituting in 5.1 and 5.2, we calculated the number of degrees of freedom per equation to be 120.08. This is adequate according to Garret and Priestley (1997).

Hung and Jo (1995) examined the issue of whether the number of factors that explain stock returns in empirical tests of the APT tends to change with different data frequencies. The estimates were performed, using asymptotic principal components analysis and maximum likelihood factor analysis. The analysis was conducted at three levels (using daily, weekly and monthly returns), to show that the rates of total explained variance to total variance, the number factors and the number of priced factors are stable across data frequencies. However, the authors note that the question whether the same macroeconomic factors reliably influence stock returns measured over various time intervals still needs to be studied. Since we are more interested in how political and economic events influence the APTM, choosing any of the three data frequencies (daily, weekly or monthly returns) should not affect the results.

The justification for using the monthly recursive LFM in the section below when the results cannot be used is not obvious at first.

Essentially, the reason is that the use of the weekly LFM narrowed our period of review from March 1988 to April 1998 to 20 October1991 to 21 June 1998. The reason for this is the unavailability of vital data from I-NET[3]. We would therefore have been unable to examine the period 1 March 1988 to 19 October 1991. By calculating the monthly LFM we were able to investigate this period.

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[2] This is the average number of risk factors in the best subset LFM over the 87 four- week periods from 20 October1991 to 21 June 1998. This figure is calculated in chapter 5 (sec 5.1.2).

[3] Daily data on all variables have been available only since the 8/8/1988 on I-NET.

5.1.1 The recursive linear factor model using monthly data

The base set of nine regressors (risk factors) was chosen in chapter 3 (sec 3.2).

The recursive LFM used was described in chapter 4 (sec 4.1).

SAS software programming was used to write a program, both with this analysis and with all subsequent model analyses, in order to identify the best subset regression equation over 120 months.

Since the Akaike's selection criterion tended to choose the same best subset as the adjusted R^2 criterion, for the sake of consistency, the regression selected was the one exhibiting the highest adjusted R^2.

An example of how the recursive LFM (best subset selection model) works is shown below for period 60 (equivalent to March 1993).

With the excess returns on the financial and industrial sector as the dependent variable, all different combinations of the nine risk factors were used as the independent variables of the OLS regression in order to choose the combination that gave the highest adjusted R^2 statistic. The data set used was from March 1990 to February 1993.

Appendix 3 lists the 512 different combinations of equations which have to be regressed in order to find which one exhibits the highest adjusted R^2 for period number 60 (March 1993). The regression shown below was chosen with an adjusted R^2 score of 0.22.

$$EPFINIIND = \beta_0 + \beta_1 RPDJ + \beta_2 RPVOL$$

where:

EPFINIIND	=	excess returns on the F & I index
β_o	=	a constant
RPDJ	=	unanticipated changes in the Dow-Jones index
RPVOL	=	unanticipated changes in the volume of shares traded on the JSE

This selection process was repeated 120 times for the 120 periods between 1 April 1988 and 31 March 1998 and the results are shown in Appendix 4.

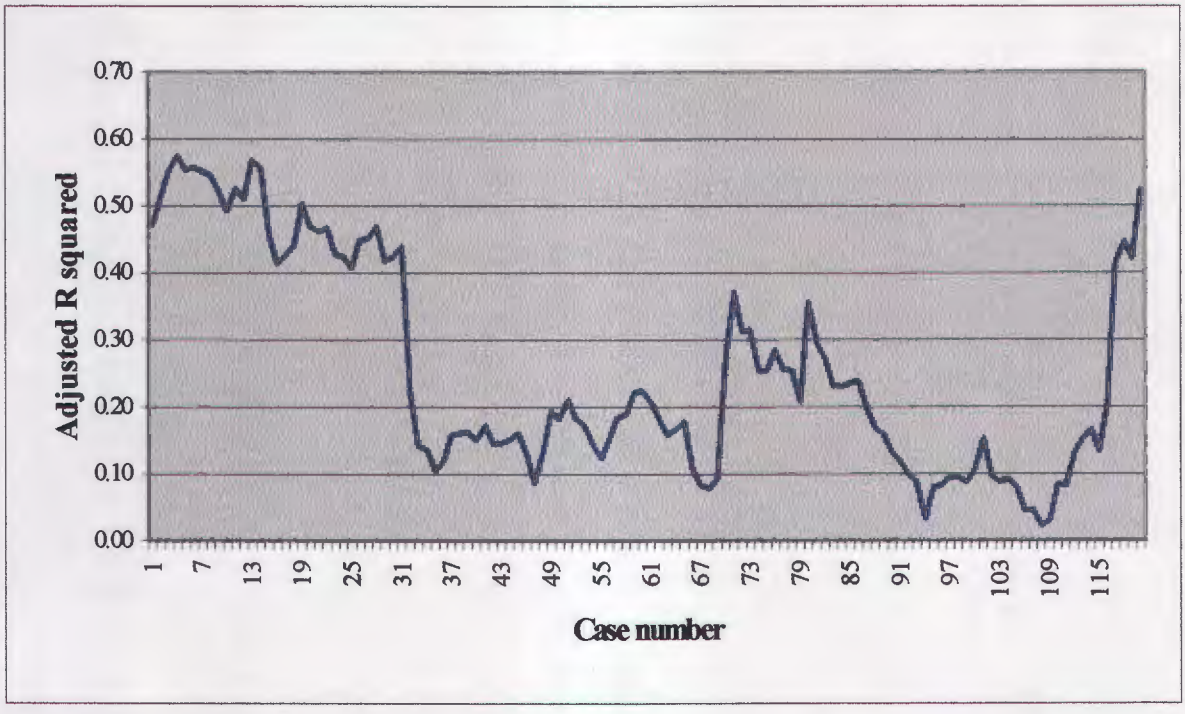
The average number of regressors in each period is 3.55 and the average adjusted R^2 for the entire period (April 1988 to March 1998) is 25 percent.

The plot of adjusted R^2 vs time (graph 5.1) shows a remarkable drop from approximately 55 percent in October 1991 to around 15 percent, fluctuating around this lower level, until the beginning of 1997, when it reverted back to the mid-50 percent.

As stated before, since the APTM will be analysed using weekly data, this section is only of interest to the extent that it helps us examine the LFM for the period 1 April 1988 to 20 October1991, which the weekly LFM does not cover.

GRAPH 5.1

Adjusted R^2 of the best monthly subset LFM vs time over the 120 month period from 1 April 1988 to 31 March 1998, using monthly data



5.1.2 The recursive linear factor model using weekly data

After the researcher had decided to use weekly data in this thesis, a number of decisions still had to be made because the following problems were encountered:

(1) Some risk factors are only published and the information provided on a monthly basis. These risk factors are the SACOB business confidence index and the consumer price index.

(2) Information on the volume of shares traded on the JSE (in R'000) was available on a daily[4] basis for only part of the period under review. Prior to that, it was available on a monthly basis.

[4] Daily data needed to calculate the mean for the week on the volume of shares traded on the JSE were only available from 25/03/91 onwards on I-NET.

(3) Even though some risk factors were available on a continuous weekly basis (Dow-Jones, gold price, term structure of interest rates, bankers' acceptance rate and dividends paid by companies in the industrial and financial sectors), these proved to be unsuitable. When the weekly data were used in the usual manner, namely Friday's closing figure is taken to represent the week, the time series exhibited excessive volatility. In time, with the use of an iterative solving technique such as the ITNLSUR, this volatility causes nonconvergence.

These problems were dealt with as follows:

(1) The two risk factors that are available only on a monthly basis (SACOB and CPI) were plotted and weekly figures were taken to be the extrapolated values between the monthly points. This procedure is available on SAS programming and is known as Proc Expand.
(2) The monthly values of the volume of shares traded on the Johannesburg Stock Exchange were converted to weekly values, by dividing the monthly values by the appropriate number of weeks in that month.
(3) As an initial attempt to solve the problem of nonconvergence, it was decided to use a moving average[5] to smooth the weekly data before extracting the unanticipated component of the risk factors and using the ITNLSUR. Although this solved the problem with the ITNLSUR technique, the autocorrelation introduced was excessive. Even though this was corrected by removing any auto-correlation going back 12 lags, the moving average procedure was abandoned. It was intuitively felt that when autocorrelation is consciously introduced and then removed by autocorrelation-correcting procedures, the variables are suspect because we could be introducing other problems which are more difficult to detect and correct. The volatility problem was eventually overcome by using the weekly mean figure instead of Friday's closing price as the representative figure for the week.

[5] Different period moving averages were attempted.

All the same procedures as those used with the monthly data were undertaken in order to extract the unexpected components of the risk factors, the only exception being that the auto-correlation was corrected for up to seven lags, instead of 12, because this was found to be sufficient.

The base data set now becomes the 156 week period from 14 August 1988 to 14 September 1988. Again, this base set moved along four weeks at a time over 87 four-week periods, each time adding four observations (current observations) and dropping four observations[6] (oldest observations).

Appendix 5 shows which risk factors are included in each LFM chosen over the 87 four-week period, along with the p value of their beta coefficient.

Table 5.4 shows the percentage of periods a regressor (risk factor) is included in the best subset.

[6] At the start of the process (period 1) the data set contained 156 weekly observations (3 years). For Period 2, the 157th, 158th, 159th and 160th weekly observation were included in the data set and the 1st, 2nd, 3rd and 4th observations were dropped. For period 3, the 161st, 162nd, 163rd and 164th weekly observations were included in the data set and the 5th, 6th, 7th and 8th weekly observations were dropped and so on. At all times the data set contained 156 weekly observations.

TABLE 5.1

Percentage of time a risk factor is priced in the LFM during the three subperiods

	DJ	GOLD	TSD	INT	IFDIV
PERIOD 1	100%	10%	0%	0%	69%
PERIOD 2	100%	0%	28%	62%	69%
PERIOD 3	100%	14%	69%	100%	0%
AVERAGE	100%	8%	32%	54%	46%
	VOL	**CRUDE**	**SACOB4**	**CPI8**	
PERIOD 1	52%	52%	7%	0%	
PERIOD 2	86%	10%	0%	0%	
PERIOD 3	76%	7%	0%	10%	
AVERAGE	71%	23%	2%	3%	

The regressors are the unexpected rate of change of: DJ = Dow-Jones index,
GOLD = dollar gold price, TSD = term structure of interest rates, INT = three-month bankers' acceptance rate, IFDIV = dividends, VOL = volume of shares traded, CRUDE = dollar Dubai crude oil spot price, SACOBI = SACOB business confidence index lagged four weeks,
CPI8 = consumer price index lagged eight weeks
p-value is the probability that the risk factor is not priced. We regard a risk factor to be priced if $p<.05$
Period 1:20 October1991 to 9 January 1994
Period 2: 10 January 1994 to 31 March 1996
Period 3: 1 April 1996 to 21 June 1998

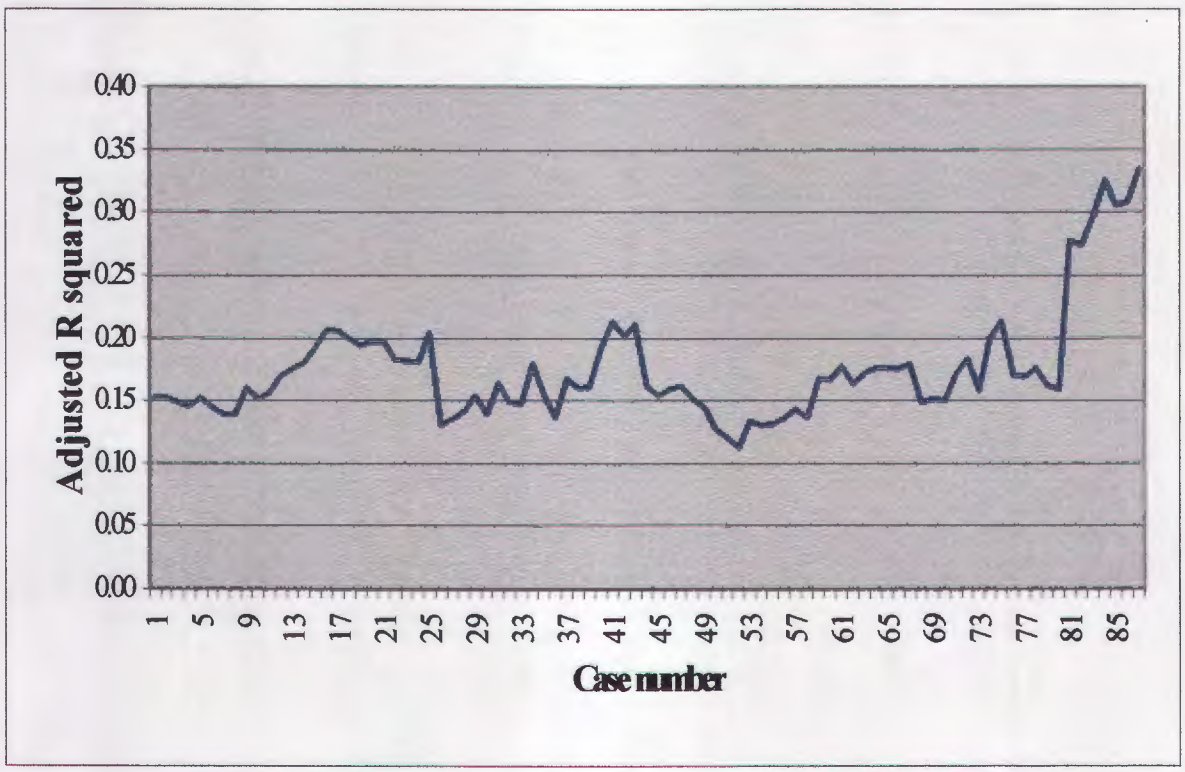
The average number of regressors in each period is 6.8[7] and the average adjusted R^2 for the entire period (20 October1991 to 21 June 1998), is 21 percent. Although the average number of regressors is high, the average number of significant factors (having a statistic of $p<0.05$) in each period is 3.3. This is comparable with Van Rensburg's (1995) findings of four significant risk factors in the LFM, using monthly data during the period January 1980 to December 1989 and the JSE's ASI as the dependent variable.

[7] Appendix 6 gives the percentage of time a risk factor appears in the LFM during the three subperiods.

A plot of the adjusted R^2 statistic for the best subset regression versus time is shown in graph 5.2.

GRAPH 5.2

Adjusted R^2 of the best monthly subset LFM vs time over the 87 periods from 20/10/1991 to 21/06/1998, using weekly data



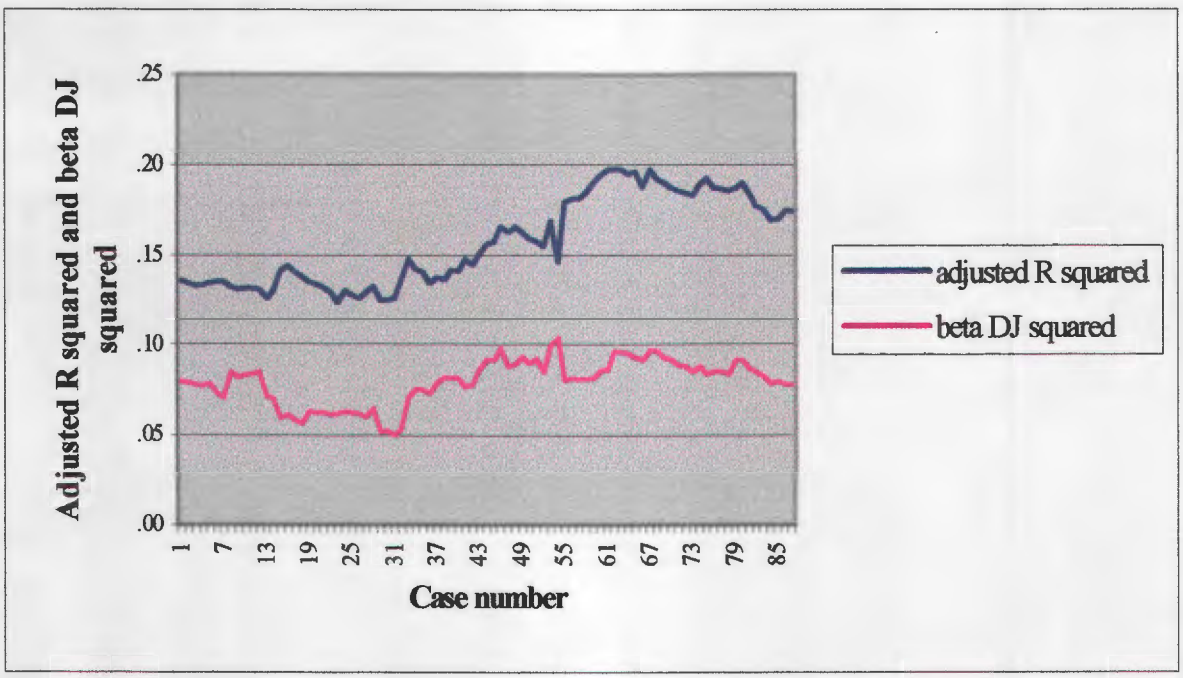
In order to see the contribution of each risk factor to the total explanatory power (adjusted R^2) of the model, the standardised beta of each risk factor, in a linear regression with the returns on the financial and industrial index as the dependent variable and the nine risk factors as the dependent variables, was calculated for each period. Each beta was then squared and a graph was plotted of β^2 versus the adjusted R^2. Since β^2 reflects the unique contribution of that particular risk factor to the overall adjusted R^2 statistic, this plot accurately reflects the unique contribution of the risk factor over the entire period. By way of

example, graph 5.3 shows the unique contribution of the Dow-Jones risk factor to the overall adjusted R^2 during the period 20 October1991 to 21 June 1998.

The same plot for the other eight risk factors is shown in Appendix 7.

GRAPH 5.3

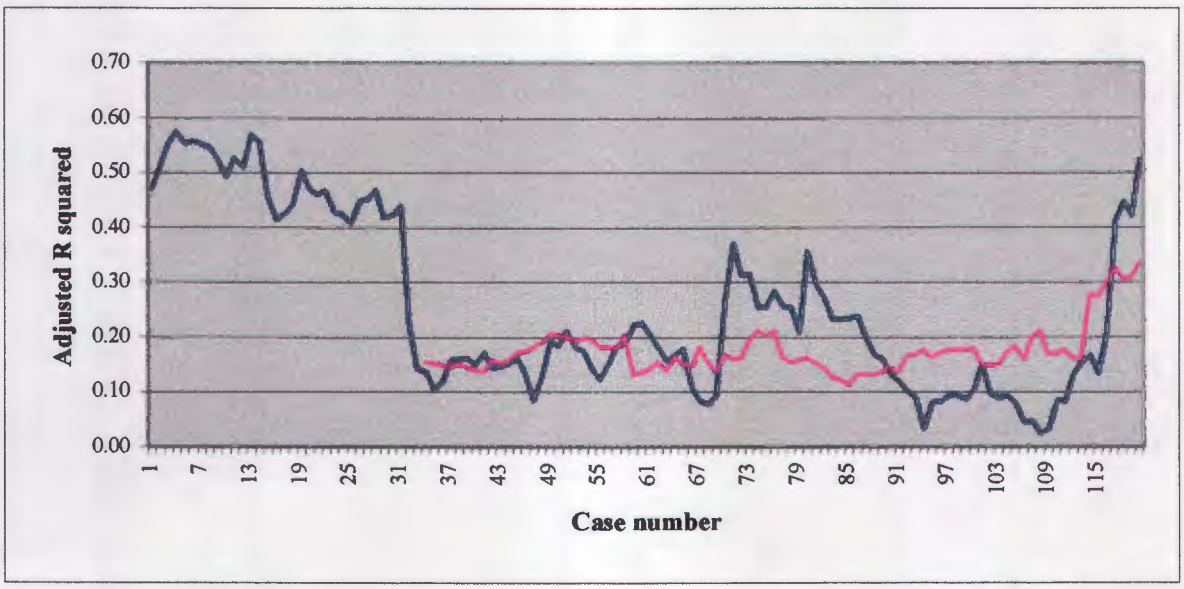
Graph showing the unique contribution of the Dow-Jones risk factor to the overall explanatory power of the linear factor model with nine risk factors, over the 87 periods from 20/10/1991 to 21/06/1998



For ease of comparison between the monthly and weekly adjusted R^2 statistic, graph 5.2 was superimposed on graph 5.1 to produce graph 5.4.

GRAPH 5.4

Graph showing the monthly and weekly adjusted R^2 of the best subset LFMs vs time over the 120 month period 1 April 1988 to 31 March 1998



As stated before, comparison for the entire period is not possible because of the unavailability of daily data between 1 April 1988 and 20 October1991.

Before comparing the two plots, the fact that the weekly plot used four-week periods, while the monthly plot used repeating periods of five weeks, four weeks and four weeks, should be borne in mind[8].

From graph 5.4, it can be seen that over the entire period, the weekly adjusted R^2 statistic is a smoothed-out version of the monthly adjusted R^2 in that it fluctuates around a limited range of low values and then rises sharply at the beginning of 1997.

[8] This means that the monthly periods do not coincide exactly.

5.2 THE ARBITRAGE PRICING THEORY MODEL

5.2.1 The ITNLSUR approach

From the previous chapter (sec 5.1.2), using weekly data, the researcher identified the best subset LFM for each period from 20 October1991 to 21 June 1998 (87 LFMs). The risk factors identified in each period were shown in Appendix 4.

To give an example, the best subset LFM for period 63 (June 1996) was found to be as follows:

$$EPFNIINDW_t = \beta_0 + \beta_1 RPDJD + \beta_2 RPDGOLDD + \beta_3 RTSDP + \beta_4 RPINTD$$

$$+ \beta_5 RPVOLD + \beta_6 RPCRUDED + \beta_7 RPCPID8$$

where:

EPFNIINDW = excess returns on the F & I index[9]

β_0 = a constant[10]

β_1 = a measure of the unique contribution of the Dow Jones risk factor to the overall correlation[11] between the seven risk factors and EPFNIINDW

RPDJD = unanticipated changes in the Dow-Jones index

[9] The excess return is calculated by subtracting the three-month treasury bill tender rate from the rate of change in the financial and industrial index. See equation 3.1.

[10] This constant would have represented E (PENDIINDW) if the risk-free rate (TBT3) had not moved across to the left- hand side of the equation.

[11] And hence the adjusted R^2 statistic.

β_2	=	a measure of the unique contribution of the dollar price of the gold risk factor to the overall correlation between the seven risk factors and EPFNIINDW
RPDGOLDD	=	unanticipated changes in the dollar price of one ounce of gold
β_3	=	a measure of the unique contribution of RTSDD to the overall correlation between the seven risk factors and EPFNIINDW
RTSDD	=	unanticipated changes in the term structure of interest rates
β_4	=	a measure of the unique contribution of RPINTD to the overall correlation between the seven risk factors and EPFNIINDW
RPINTD	=	unanticipated changes in the three-month bankers' acceptance rate
β_5	=	a measure of the unique contribution of RPVOLD to the overall correlation between the seven risk factors and EPFNIINDW
RPVOLD	=	unanticipated changes in the volume of shares traded on the JSE
β_6	=	a measure of the unique contribution of RPCRUDED to the overall correlation between the seven risk factors and EPFNIINDW
RPCRUDED	=	unanticipated changes in the dollar price of crude oil

β_7 = a measure of the unique contribution of RPCPID8 to the overall correlation between the seven risk factors and EPFNIINDW

RPCPID8 = unanticipated changes in the consumer price index lagged eight weeks

Imposing the arbitrage pricing restrictions on the intercept (β_0), which means restricting the values of the risk premia (λs) to be constant across all 57 equations, ensures that all assets with the same sensitivity profiles will have the same expected returns (ch 2, sec 2.3.2).

The effect of this on the example for period 63 is that it will produce the following set of 57 simultaneous equations, which must be solved using 156 observations (June 1993 to May 1996) using the ITNLSUR technique:

$$\rho_{it} = \beta_{i1}\lambda_1 + \beta_{i2}\lambda_2 + \beta_{i3}\lambda_3 + \beta_{i4}\lambda_4 + \beta_{i5}\lambda_5 + \beta_{i6}\lambda_6 + \beta_{i7}\lambda_7 + \beta_{i8}\lambda_8$$

$$+ \beta_{i1}\text{RPDTD} + \beta_{i2}\text{RPDGOLDD} + \beta_{i3}\text{RTSDD} + \beta_{i4}\text{RPINTD}$$

$$+ \beta_{i5}\text{RPVOLD} + \beta_{i6}\text{RPCRUDED} + \beta_{i7}\text{RPCPID8} + \beta_{i8}\text{RMF}_t + \varepsilon_{it}$$

for: $i = 1, \ldots\ldots\ldots\ldots 57$ and $t = 1, \ldots\ldots\ldots\ldots 156$

Note the following:

(1) $\lambda_1 \ldots \lambda_8$ is restricted to be equal across all 57 equations and $\beta_{i1} \ldots, \beta_{i7}$ is restricted to be the same when showing the sensitivity of a particular risk premium (λ) and corresponding risk factor.

(2) The residual market factor (RMF) is calculated by the following OLS regression:

$$\text{EPFNIINDW}_t = \beta_0 + \beta_1\text{RPDJD} + \beta_2\text{RPDGOLDD} + \beta_3\text{RTSDP} + \beta_4\text{RPINTD}$$

$$+ \beta_5\text{RPVOLD} + \beta_6\text{RPCRUDED} + \beta_7\text{RPCPID8} + \varepsilon_{\text{RMF}}$$

where :

RMF = ε_{RMF}

(3) In order to make the effect of each risk factor comparable all variables must be standardised. This also ensures that the mean of all the risk factors is brought to zero over the period June 1993 to May 1996.

(4) ε_{it} is the idiosyncratic risk of each share and if enough assets are used, it should average out to zero. The SUR approach assumes that these errors are correlated across the 57 equations and that their expected mean is zero.

5.2.2 The N3SLS approach

As explained in section 3.3 of chapter 3, this approach used an "approximate factor" version of the APTM, to take into consideration the possibility that the return on some assets may be correlated with the errors in their LFMs.

Instead of the RMF, the excess returns on the market portfolio (EMR) were used as the 10th risk factor. The market portfolio equation was added to the 57 asset return equations to make a total of 58 simultaneous equations to be solved.

The market portfolio equation is :

$$EMR = \beta_1\lambda_1 + \beta_2\lambda_2 + \ldots + \beta_9\lambda_9 + \beta_1\, RPDJD + \beta_2\, RPDGOLDD + \ldots + \beta_9\, RPSACBD4$$

The following instruments were used:

(1) RPDJD = unanticipated rate of change in the Dow-Jones index

(2) RPDGOLDD = unanticipated rate of change in the dollar price of one ounce of gold

(3)	RTSDD	=	unanticipated changes in the term structure of interest rates
(4)	RPINTD	=	unanticipated rate of change in the three-month bankers' acceptance rate
(5)	RPVOLD	=	unanticipated rate of change in the volume of shares traded on the JSE
(6)	RPCRUDED	=	unanticipated rate of change in the dollar price of crude oil per barrel
(7)	RPCPID8	=	unanticipated rate of change in the consumer price index lagged eight weeks
(8)	RPIFDIVD	=	unanticipated rate of change in the total dividends paid by companies in the financial and industrial sectors
(9)	RPSACBD4	=	unanticipated rate of change of the SACOB business confidence index lagged four weeks
(10)	$RPDJD^2$	=	the square of unanticipated rate of change in the Dow-Jones index
(11)	$RPDGOLDD^2$	=	the square of unanticipated rate of change in the dollar price of one ounce of gold
(12)	$RTSDD^2$	=	the square of unanticipated changes in the term structure of interest rates
(13)	$RPINTD^2$	=	the square of unanticipated rate of change in the three-months bankers' acceptance rate

(14) $RPVOLD^2$ = the square of unanticipated rate of change in the volume of shares traded on the JSE

(15) $RPCRUDED^2$ = the square of unanticipated rate of change in the dollar price of crude oil per barrel

(16) $RPCPID8^2$ = the square of unanticipated rate of change in the consumer price index lagged eight weeks

(17) $RPIFDIVD^2$ = the square of unanticipated rate of change in the total dividends paid by companies in the financial and industrial sectors

(18) $RPSACBD4^2$ = the square of unanticipated rate of change in the SACOB business confidence index lagged four weeks

The market portfolio was instrumented with:

(1) the return on the mining financial index
(2) the squared value of the return on the mining financial index
(3) fitted values from a regression of the excess return on the market portfolio (F & I index) with the nine risk factors
(4) the squared values of the fitted values from a regression of the excess returns on the market portfolio with the nine risk factors

The EDS submodule of the SAS package was again used.

5.2.3 Results of the two approaches

The ITNLSUR and N3SLS are iterative techniques. This gave rise to the following problems:

(1) The calculations were computationally demanding.
(2) Local instead of general solutions were sometimes found.
(3) There was nonconvergence of iterations.

These problems were dealt with as follows:

(1) Allowance was made for this, and the programme was left to run overnight on a powerful computer.
(2) Kim and Sall (1993:574) mention this problem and warn that it is difficult to detect because the procedure will appear to have succeeded. They suggest that the way to guard against this is by running the estimation with two different minimisation techniques, namely the Gauss and Marquardt techniques.
(3) The problem of nonconvergence is more difficult to deal with and arises when the data are ill-conditioned. In this case, the computer will continue with the iterations indefinitely. Different approaches were followed in order to deal with these problems. Firstly, the convergence criterion was relaxed; secondly the number of permitted iterations was increased; thirdly, the covariance matrix of a similar model was used as the starting value of the iteration; and lastly share returns that had an abnormally high or low correlation with the risk factors were removed from the system. None of these approaches succeeded and the problem of nonconvergence was dealt with by comparing the results of the two techniques and by using the results of the technique (ITNLSUR or N3SLS) which converged. This problem was encountered in less than 10 percent of the time periods tested.

Appendix 8 shows the results of the ITNLSUR and the N3SLS procedures on the 87 LFMs using both the Gauss and the Marquardt minimisation techniques, convergence criterion of .0001 and a maximum permissible number of 200 iterations.

The ITNLSUR technique did not converge for periods 20, 34, 36, 37, 39, 41, 44, 45, 46, 57, 69, 70, 71, 84 and 85.

In order to better understand how the pricing of a risk factor varies with time, the entire period from 20 October1991 to 21 June 1998 (87 months) was broken up into three equal subperiods (29 months each). This is essential as risk factors tend not to be included in the LFM continuously and therefore will not have a chance to show if they are priced or not on a month-to-month basis. However, a trend can be established if a comparison is made on a 29-month period to period.

A revealing way to compare the results of the two techniques (ITNLSUR and N3SLS) is to tabulate the percentage of time that each technique shows a risk factor to be priced per 29-month period.

Table 5.2 gives a breakdown on how the risk factors are priced over time using the ITNLSUR and N3LS techniques. As stated previously, the ITNLSUR technique failed to converge in 15 out of the 87 time periods. However, this refers to the ITNLSUR technique using the Gauss minimisation technique. There were instances when using the Marquardt minimisation method where the ITNLSUR technique converged over these 15 time periods. If the results over these instances could be confirmed with the N3SLS techniques, then those results were used. This happened over the following runs: 34, 36, 39, 41, 44, 45, 46, 57, 69, 70, 71 and 84.

TABLE 5.2

Percentage of time a risk factor is priced in the APTM during the three subperiods

	DJ		GOLD		TSD	
Period	**ITNLSUR**	**N3SLS**	**ITNSLUR**	**N3SLS**	**ITNLSUR**	**N3SLS**
1	90%	72%	34%	7%	3%	0%
2	100%	38%	4%	8%	42%	42%
3	43%	58%	18%	12%	57%	50%
Average	78%	56%	19%	9%	34%	31%
	INT		**IFDIV**		**VOL**	
Period	ITNLSUR	N3SLS	ITNSLUR	N3SLS	ITNLSUR	N3SLS
1	24%	14%	41%	38%	52%	59%
2	42%	42%	50%	25%	12%	33%
3	61%	46%	0%	0%	21%	38%
Average	42%	34%	30%	21%	28%	43%
	CRUDE		**SACB**		**CPI**	
Period	ITNLSUR	N3SLS	ITNSLUR	N3SLS	ITNLSUR	N3SLS
1	3%	10%	52%	59%	0%	0%
2	38%	17%	0%	0%	33%	13%
3	29%	19%	21%	19%	29%	38%
Average	23%	15%	24%	26%	21%	17%

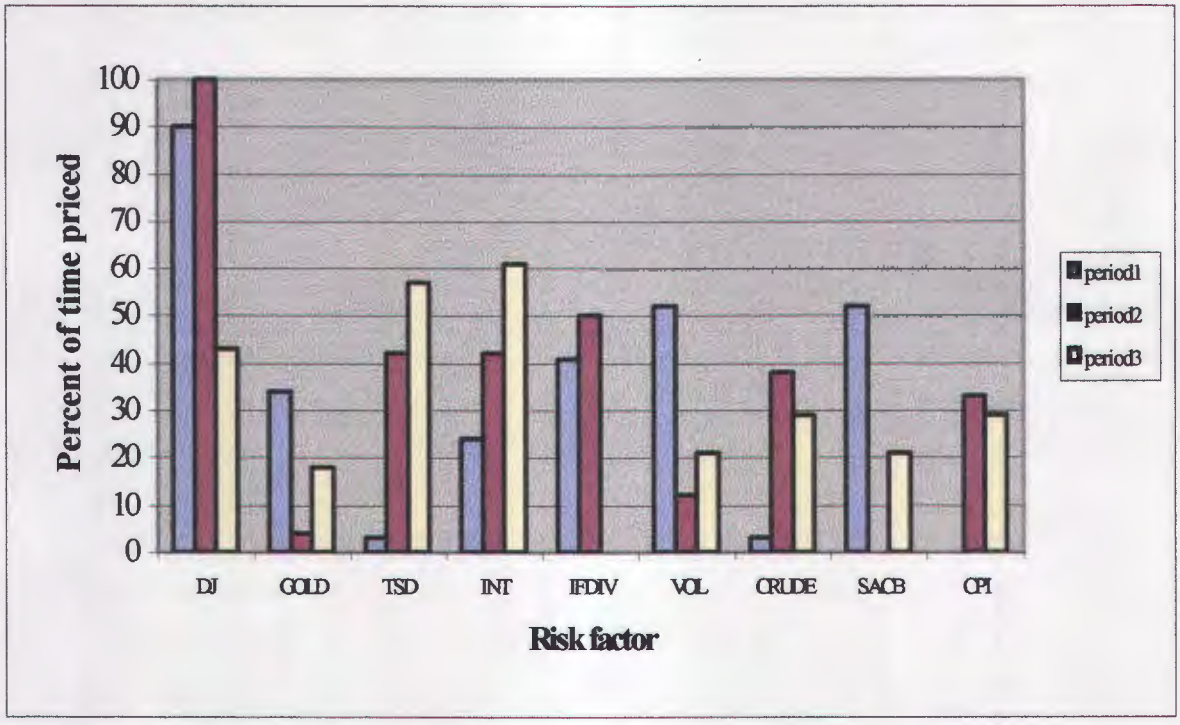
The regressors are the unexpected rate of change of: DJ = Dow-Jones index, GOLD = dollar gold price, TSD = term structure of interest rates, INT = three-month bankers' acceptance rate, IFDIV = dividends, VOL = volume of shares traded, CRUDE = dollar Dubai crude oil spot price, SACB = SACOB business confidence index lagged four weeks, CPI = consumer price index lagged eight weeks
p-value is the probability that the risk factor is not priced. We regard a risk factor to be priced if $p<.05$
Period 1:20 October1991 to 9 January 1994
Period 2: 10 January 1994 to 31 March 1996
Period 3: 1 April 1996 to 21 June 1998

An unintended contribution of this thesis was to show that both the ITNLSUR and the 3NLS techniques are applicable on the JSE because they tended to produce similar results.

Graph 5.5 shows histograms of how risk factors are priced over time using the ITNLSUR technique.

GRAPH 5.5

Histograms of how risk factors are priced over time using the ITNLSUR technique during the period 20/10/1991 to 21/06/1998



The risk factors are the unexpected rate of change of: DJ = Dow-Jones index, GOLD = dollar gold price, TSD = term structure of interest rates, INT = three-month bankers' acceptance rate, IFDIV = dividends, VOL = volume of shares traded, CRUDE = dollar Dubai crude oil spot price, SACB = SACOB business confidence index lagged four weeks, CPI = consumer price index lagged eight weeks
p-value is the probability that the risk factor is not priced. We regard a risk factor to be priced if $p<.05$
Period 1:20 October1991 to 9 January 1994
Period 2: 10 January 1994 to 31 March 1996
Period 3: 1 April 1996 to 21 June 1998

The following trends can be seen from Graph 5.5:

(1) The Dow-Jones risk factor showed a decrease in importance over the three subperiods. It regressed from being the most important risk factor in the APTM in the first subperiod to being the third most important during the third subperiod. Overall, because it had been consistently priced, it was still the most important risk factor over the entire period.

(2) The risk factors associated with political events showed a decrease in importance over the three subperiods. The SACOB business confidence index as a risk factor was jointly the second most important risk factor with the volume risk factor, during the first subperiod, but dropped to being the joint sixth most important in the third subperiod. The volume of shares traded on the JSE as a risk factor started off as the joint second most important risk factor, but dropped to being the joint sixth most important during the third subperiod.

(3) The dollar price of gold has shown a steady decline - from being priced 34 percent of the time during the first subperiod - to becoming the second least important risk factor in the third subperiod (18%).

(4) The total dividends paid by companies in the financial and industrial index as a risk factor dropped dramatically in importance from being priced 41 percent of the time during the first period down to 0 percent during the third subperiod.

(5) The term structure of interest rates increased dramatically in importance as a risk factor from being almost unpriced during the first sub-period, to being the second most frequently priced factor in the third subperiod.

(6) The three risk factors associated with inflation and inflation expectations, namely the consumer price index, the dollar price of crude oil and the rate of change in the three-months bankers' acceptance rate, have become increasingly more important. The rate of change in the three-months bankers' acceptance rate is the second most frequently priced risk factor after the Dow-Jones index over the entire three subperiods. Although the dollar price of crude oil and the consumer price index have shown an increase in importance from subperiod one to subperiod two, and finally to subperiod three, because they started from a low base, they only managed to finish as the joint seventh and eighth most important risk factors respectively, over the entire three subperiods.

CHAPTER 6
INTERPRETATION OF THE RESULTS

6.1 INTRODUCTION

In this final chapter the work done thus far is matched to the objectives of the thesis.

Specifically, the research problem, the component subproblems into which it was broken down and the matching hypotheses that were formulated from the subproblems are examined here, with the objective of ascertaining whether the results obtained are compatible with the objectives that were set out at the beginning of the thesis.

Of greater importance is the fact that the results are interpreted in this chapter and although the interpretation involves the use of economic theory which would make some of these interpretations subjective, this section represents the distillation of all the research carried out thus far for this thesis.

Clearly, the scope of the work involved and the different approaches that were possible could not be anticipated, with the result that, at the end of this chapter, recommendations are made for future research.

6.2 RESEARCH HYPOTHESES AND RESEARCH PROBLEM REVISITED

6.2.1 The first subproblem and hypothesis

The first subproblem was as follows:

To establish that the impact of political and economic events has changed the specification of the linear factor model, described by the arbitrage pricing theory for the financial and industrial sector of the JSE, during the period from 1988 to 1998.

The matching hypothesis was as follows:

A different set of financial and macroeconomic variables will be specified in the linear factor model, assumed by the arbitrage pricing theory, for the period before and after a regime switch caused by an economic or political event (events).

The objectives of the first subproblem were met, because the results showed that important political and economic events do change the specification of the linear factor model.

Also, the hypothesis was confirmed in that different risk factors are specified before and after a regime switch.

However, it was found that the change in specification is not immediately apparent, but takes time to manifest itself as it works though the system by affecting the economic environment.

The period between the release of Nelson Mandela and the settling in of the new government was so crowded with instances of major political and economic events that the specification of the LFM and the predictive powers of the risk factors were severely affected from approximately October 1991 to the beginning of 1997.

6.2.2 The second subproblem and hypothesis

The second subproblem was stated as follows:

To confirm that any change in the specification of the linear factor model is translated into a change in the specification of the nonlinear asset pricing model described by the APT.

The matching hypothesis was as follows:

Any change in specification of the LFM will be translated into a change in the specification of the nonlinear asset pricing model described by the APT.

Clearly this hypothesis was not confirmed and the objectives of the second subproblem were not met.

The conventional way of testing the APTM (Van Rensburg 1996) is to find the most significant risk factors in the LFM and then to confirm that they are priced in the APTM. When this did not happen for one particular risk factor in Van Rensburg (1996:110), he stated the following:

> It is, perhaps, surprising to note that Gold price risk is not priced given the importance of this variable to the South African economy. Mining shares are not underrepresented in the share sample and, in fact, their proportion of market capitalisation is higher than that of the industrial component of the sample. However, examining the magnitudes of the sensitivity coefficients estimated in Van Rensburg (1995), it can be seen that, although the mining and mining financial sectors displayed significant positive sensitivities to unexpected movements in the gold price, the industrial and financial share portfolios were not affected by this variable, suggesting the possibility that it is more industry than market related in the breadth of its influence.

In fact it was found that the "magnitudes of the sensitivity coefficients" had no predictive power as to whether or not a risk factor was priced.

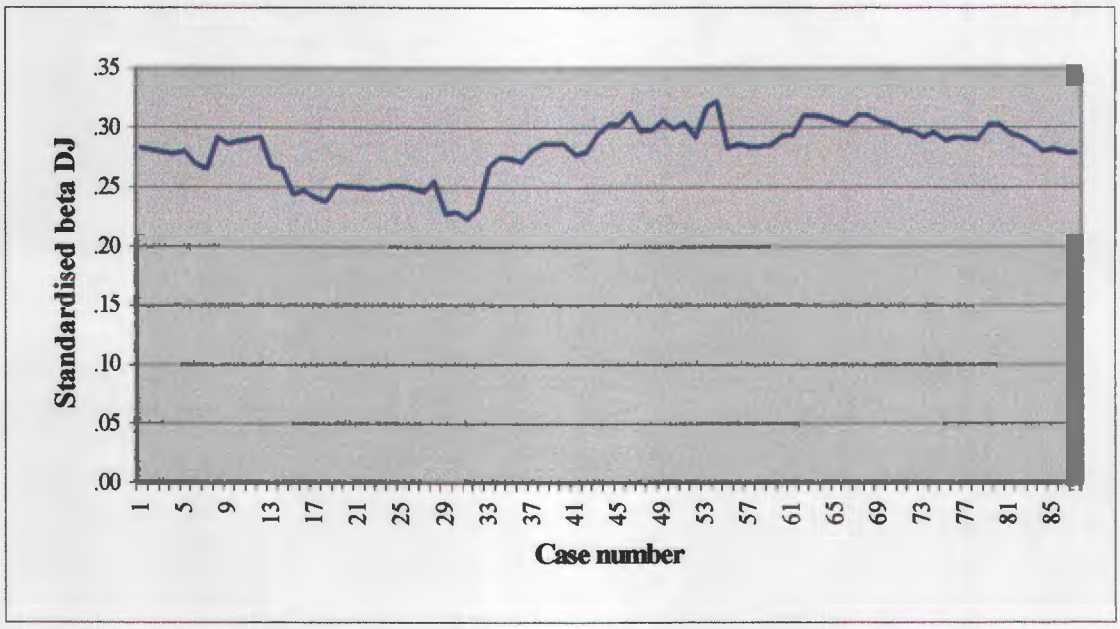
For example, in one particular period (case number 63), a risk factor (DJ) showing a level of significance of more than 99 percent in the LFM was found not to be priced in the APTM, while a risk factor (CPI), showing significance at a level of confidence of 80 percent was found to be priced in the APTM at a 99 percent level of confidence. This conclusion is also obvious if a comparison is made between tables 5.1 and 5.2, showing which risk factors were priced in the LFM and APTM respectively, over the three subperiods.

A possible explanation for this anomaly can be found if the standardised beta of each risk factor plotted against time is examined (the standardised betas are obtained by linear regression using the excess returns on the F & I index as the dependent variable and the nine risk factors as the independent variables over the 87 time periods).

If we examine the plot of the Dow-Jones beta versus time shown below (graph 6.1)[1], it can be seen that a risk factor must show a significant standardised beta consistently over time before we can expect it to be priced.

GRAPH 6.1

Graph of the standardised beta of the Dow-Jones risk factor vs time over the 87 periods from 16/10/1988 to 21/06/1998



However, this observation offers us a rough guideline and in no way can it be used in practice to calculate the potential performance of a risk factor in the APTM.

[1] Plots of the standardised betas of the other eight risk factors vs time can be found in Appendix 9.

6.3 SUMMARY OF RESULTS

In chapter 5 it was seen that the time period that was studied intensively with respect to the APTM was narrowed down from 1 April 1988 to 31 March 1998 to 20 October 1991 to 21 June 1998 because of the nonavailability of daily data on the I-Net from 1 March 1985 to 8 August 1998.

This is not considered an obstacle to the attainment of the objectives of this thesis because the analysis of the LFM using monthly data over the entire period (1 April 1988 to 31 March 1998) showed that the LFM was only perturbed around October 1991.

It was found that an illuminating way to determine how the pricing of a risk factor varies over time would be to divide the 87 four-week periods into three equal subperiods and to study the behaviour of each risk factor from subperiod to subperiod.

20 October 1991 to 9 January 1994 (first subperiod)

During this period the four most frequently priced risk factors in the APTM in order of importance were:

(1) the Dow-Jones index
(2) the volume of shares traded on the JSE
(2) the SACOB business confidence index
(3) dividends paid by companies in the industrial and financial sectors

It comes as no surprise that the Dow-Jones index was the most frequently priced risk factor because the influence of this index on world markets is well documented.

In this period leading up to the national elections, after an extended period of political manoeuvring, it is not unexpected that the risk factor proxying for political events would be the joint second most frequently priced risk factor.

It seems reasonable to expect that the prevailing uncertainty at that time would also influence the confidence of the business community (SACOB business confidence index) to such an extent that this factor would become an important risk factor priced in the APTM (joint second). The manner in which the SACOB BCI, which was designated as a proxy for economic events, has become important during the turbulent period before the general elections would suggest that it is now acting as a proxy for political events in the country. It appears that as SACOB became involved during the transitional phase before the national elections as an honest broker (see chapter 3 section 3.1.3.2) for political change, the business confidence index became politicised, with the result that the index began to reflect the confidence of business[2] in the political future of this country and thus effectively became a proxy for political events. After the general elections when a democratically elected government had been installed and there was no need for SACOB to play a political role, the index reverted back to becoming an indicator of business confidence released monthly by SACOB for the benefit of its members, who use the index to ascertain the effect of the economic environment on their businesses.

An unexpected finding was, however, that the dividends paid by companies in the financial and industrial sectors were the fourth most frequently priced risk factor, especially in view of the fact that tax on dividends was abolished only in March 1990, in other words before it had had time to gain significance. However, on reflection, an explanation for this significance could be that before South Africa emerged from its isolation from the international community (April 1994), South African companies had very little opportunity for overseas expansion. During this period of isolation, successful South African companies, after buying as many local companies as they could, had no other option but to distribute their profits in the form of dividends. This argument was raised previously in chapter 3 to explain the shape of the dividend yield graph. This would explain why dividends paid would be a significant risk factor (predictor variable) during South Africa's years of isolation, only to become totally insignificant once that isolation was ended.

[2] Possibly as a result of the way they responded to the manufacturing survey, which is one of the 13 indicators making up the SACOB BCI. Unfortunately SACOB gives no indication of the weight of each indicator in the total index.

Van Rensburg (1996) found three factors that were applicable to the JSE to be priced in the APTM during the period from January 1980 to December 1989. These were: unexpected movements in the returns on the Dow-Jones industrial index, unexpected movements in the term structure of interest rates and unexpected movements in inflation expectations[3].

Clearly, the specification of the APTM has changed. The low explanatory power of the LFM (adjusted R^2 approximately 15%) would suggest that in the event of a major regime switch in the economy such as the one introduced by the release of Nelson Mandela and the unbanning of the ANC, learning may take a long time to complete, as investors attempt to model, say, the new relationship between inflation, nominal interest rates and stock returns.

10 January 1994 to 31 March 1996 (second subperiod)

During this period the four most frequently priced risk factors in the APTM in order of importance were:

(1) the Dow-Jones index
(2) the three-month bankers' acceptance rate
(3) the term structure of interest rates
(4) dividends paid by companies in the industrial and financial sectors

1 April 1996 to 21 June 1998 (third subperiod)

The risk factors that tended to be priced the most frequently during this period in order of importance were:

(1) the three months bankers' acceptance rate
(2) the term structure of interest rates
(3) the Dow-Jones index
(4) the consumer price index
(5) the price of crude oil

[3] Although Van Rensburg used returns on the JSE ASI as his dependent variable and this thesis used returns on the JSE industrial and financial index, the high correlation between the two indices would suggest that they are comparable.

Comparing subperiod two with subperiod three, we see that the top three risk factors priced during these subperiods are the same. The fourth most frequently priced risk factor in subperiod two, namely dividends paid by companies in the industrial and financial sectors, diminished dramatically in importance in subperiod three for reasons that were discussed above.

The fact that the second and third subperiods (10 January 1994 to 31 March 1996 and 1 April 1996 to 21 June 1998) reveal that the same risk factors tend to be priced suggests that as the first subperiod coincided with the preparations for the 1994 national elections the second and third subperiods, by virtue of their being similar, could be merged into a single post-election period stretching from 10 January 1994 to 21 June 1998.

Clearly, the specification of the APTM has changed since the national elections in April 1994. The fact that the new set of risk factors gradually increased in importance after this date would suggest that the new specification is more stable. This is confirmed by the higher explanatory power that the LFM has for stock returns (adjusted R^2 approximately 22%). Since all the price risk factors with the exception of the Dow-Jones index are proxies for economic events, it would appear that the economic environment now shapes the APTM.

The most important economic event after the national elections was South Africa's joining the global economic community. According to Stals (1998), South Africa has removed about 75 percent of the exchange controls that existed four years ago. All controls applicable to nonresidents, such as the two-tier exchange rate system for investments in South African equities and securities by nonresidents, have been removed. Controls applicable to outward investments by residents have also been gradually relaxed. In fact, according to Stals (1998): "nonresidents are completely free to bring funds into South Africa and to repatriate funds, for whatever purpose."

The consequence of this is that the mobility of capital can make it extremely difficult to delink the rates of return on financial assets from those prevailing abroad. Bodie, Kane and Marcus (1995) regard the level of interest rates as perhaps the single most important macroeconomic factor in investment decision making.

Interest rates influence equity prices in at least two ways:

(1) by altering the return from financial instruments that compete with equities
(2) by changing the cost of funds needed to do business

However, there is a more subtle way in which the interest rate level influences stock prices, namely, the perceived expectations of how interest rates will behave.

Because the level of interest rates is perhaps the most important macroeconomic factor, expectations about the behaviour of interest rates are likely to be the most important consideration in the minds of investors when buying equities.

According to Obstfeld (1995:135) the prices of assets such as long bonds, stocks and storable commodities depend on potentially volatile expectations about current as well as future economic conditions. The prices of these assets respond immediately and often sharply to actual news or rumours about economic fundamentals.

Economic news can affect expectations regarding interest rates. We know that interest rates are sensitive to expectations regarding inflation. Interest rates will respond to any economic news which results in a change in such expectations.

For example, a higher M3 money supply growth figure than the market expected will change the market's perception of the future course of interest rates[4]. It would also have an immediate effect on bond prices. If the released CPI figure is substantially higher than the markets thought it would be, interest rate expectations will become more bearish. Again, bond prices will respond immediately.

[4] Investors will be concerned that the Reserve Bank might view this as an indication of an imminent increase in inflation which might prompt the Reserve Bank to increase the bank rate.

From the list of the five most important risk factors during the period 1 April 1996 to 21 June 1998, it can be seen that four are proxies for economic news events. These are: the bankers' acceptance rate, crude oil, CPI and the term structure of interest rates. These risk factors will be shown in the next few paragraphs to reflect the internationalisation of the capital markets in South Africa after the elections by becoming effective proxies for interest rate expectations.

Interest rate expectations

(1) The three-month bankers' acceptance rate overtook the Dow-Jones index in the third subperiod (1 April 1996 – 21 June 1998) to become the most important risk factor.

The objective of the Reserve Bank is to protect the value of the rand; this can effectively be translated to mean that the Reserve Bank will fight inflation. Dr Stals (1998:38) has indicated that the Reserve Bank's objective is to bring the inflation rate in line with that of South Africa's main trading partners. According to Nel (1993) since the mid-nineteen-eighties, the monetary authorities have relied almost exclusively on the Bank rate to serve as the domestic instrument of monetary control. Therefore any increase in inflation rates or any expectations of an increase in inflation will prompt the Reserve Bank to tighten the bank rate, and by extension the BA rate, an action or impending action that will exert an influence on the JSE.

A recent example that will illustrate why this is the case would be the time when, contrary to the prevailing course of events, there was a sudden outflow of capital from the country. This sudden outflow of funds drained liquidity from the domestic money market and put upward pressure on money market interest rates. The Reserve Bank had two basic choices:

(1) to inject more money into the banking system and thereby increase the money supply growth rate but at the same time boost inflation
(2) to raise the repo rate

It decided to allow the repo rate, and consequently the bankers' acceptance rate, to rise. From the above argument it can be seen that the internationalisation of the capital markets in South Africa has strengthened the predictive powers of the BA rate over returns on the JSE.

(2) The CPI and crude oil have become the fourth and fifth most important risk factors respectively in the third subperiod (1 April 1996 – 21 June 1998). The reason for this is that they have now been targeted by the Reserve Bank.

Dr Stals (1998:38) has indicated that the Reserve bank focuses mainly on "core" or underlying inflation[5], that is the change in the overall CPI excluding the price of food, the cost of home ownership and value added tax. The objective of the bank is to bring "core" inflation more in line with that of South Africa's main trading partners. Since a rise in underlying inflation is of concern to the Reserve Bank because it indicates that fundamental inflationary forces are at work, such a rise would induce the Reserve Bank to follow a stricter monetary policy.

It was seen in chapter 3 sec 3.1.3.2 that because of its correlation with imported PPI the crude oil dollar price provides an indication of the trend that consumer prices will follow. From the argument in the previous paragraph this relationship was confirmed.

The CPI has therefore become more important as a risk factor as it influences the Reserve Bank's monetary policy , which in turn influences expectations regarding interest rates. This trend is confirmed by Cooper and Fraser (1993:209) who stated that "In recent years, inflation has been one of the most pervasive influences on interest rates".

The effect of the internationalisation of the capital markets in South Africa has been to increase the importance of these two risk factors in the APTM applicable to the JSE.

[5] This would magnify the importance of the dollar price of crude oil as a risk factor.

(3) The term structure of interest rates has become the second most important risk factor in the third subperiod (1 April 1996 – 21 June 1998).

Following the internationalisation of the capital markets in South Africa the Reserve Bank has adopted a stricter monetary control policy to bring inflation in line with that of South Africa's main trading partners (Stals 1988:38). According to Nel (1996:169) "the yield curve is basically the result of monetary policy". Since mid-1995 the real rate (the prime rate minus the inflation rate) has dramatically increased in comparison with the prime rate because of the stricter monetary policies pursued by the Reserve Bank. This has caused the fixed interest market to become more attractive and has had a negative effect on equity prices. This inverting of the yield curve was discussed in chapter 3.

The fact that pressure to be internationally competitive has forced the Reserve Bank to adopt an interest rate policy severe enough to invert the yield curve is a good example of how the new economic order has increased the influence of the term structure of interest rates on the APTM applicable on the JSE.

To summarise, the situation that prevailed in South Africa before the national elections were held in April 1994 was that the National Party government was unable to govern effectively during the period between the unbanning of the ANC and the elections. During this transitional period it became a "lame duck" government unable to take any major economic decisions, with the result that economic policy was not sensitive to the economic environment. In so far as interest rates were not governed by market forces, they had no predictive powers over stock returns. This explains why the Dow-Jones index was the most important risk factor during this period in explaining stock returns.

The effect of South Africa's joining the global economic community after the elections has been to make interest rates sensitive to the economic environment. Therefore it is not surprising that they are now showing a greater ability to predict returns than the Dow-Jones index, with the result that the Dow-Jones index is now the third most important risk factor as a predictor of stock returns.

6.4 CONCLUSION

By treating the APTM as a dynamic model instead of a static one, the researcher was able to establish that the specification of the APTM applicable to the F & I index on the JSE had undergone a change over the period under review (16 October 1988 to 21 June 1998). It was found that the APTM is not stationary and that it must be continuously tested before it can be used as political and economic events can change its specification. It was also found that political events had a more direct effect on the specification of the APTM than did economic events, which influenced the APTM by first influencing the economic environment in which it operated.

The conventional approach that would have evaluated important political and economic events, case by case, to determine whether they affected the linear factor model (LFM), and subsequently the APTM, could not be used since no correlation was found between the pricing of a risk factor in the LFM and its subsequent pricing in the APTM. This necessitated a new approach which amounted to working backwards and finding a relationship with a political or economic event when a change in the specification of the APTM was detected.

By examining the nature of the risk factors in the APTM, the researcher was able to conclude that political events changed the specification of the APTM in late 1991. Since the national elections in April 1994, the acceptance of South Africa into the world community and the globalisation of its economy have meant that there has been another change in the specification of the APTM and that a different set of risk factors primarily influenced by economic events is currently priced in the APTM. These risk factors are the same as those that were found to be priced in the APTM in the study by Van Rensburg in 1990, the only difference being that the Dow-Jones index is no longer the dominant risk factor, because it has been overtaken in importance by two risk factors proxying interest rate expectations (the BA rate and the term structure of interest rates).

6.5 SUGGESTIONS FOR FURTHER RESEARCH

As it is now clear that the conventional method of testing the APTM by first determining which risk factors are significant in the LFM offers limited benefits, the approach adopted in this thesis is one way of overcoming this shortcoming. Garrett and Priestley (1997) adopted another approach in their analysis of the APTM applicable to the London Stock Exchange where candidate macroeconomic and financial factors were tested directly in the APTM by using the N3SLS technique. A variant of this approach, which would entail subtracting one factor at a time from the APTM consisting of all risk factors and then testing to see which combination of risk factors increases the explanatory power of the APTM, was considered in the pursuit of a viable testing method in this thesis. It was found to be impractical mainly because of the large number of risk factors involved. A suggestion for further research would be to develop a method of screening risk factors and identifying the most important ones (possibly using standardised betas) and modifying the methodology mentioned above to make it usable for the JSE.

It was found that the APTM is not stationary and that it must be continuously tested before it can be used as political and economic events can change its specification. These findings applied to the financial and industrial index of the JSE. A suggestion for further research would be to use the methodology developed in this thesis and test the APTM applicable to the FT-SE100 index of the London Stock Exchange. Political and economic events such as those related to Britain's relationship with the European Union could then be evaluated to see if they have caused any change in the specification of the APTM.

APPENDIX 1

Annual index for the period January 1988 to June 1998 listing articles on South Africa published by *The Economist* during each of these years

POLITICAL & ECONOMIC EVENTS OVER THE PERIOD STUDIED AS REPORTED IN *THE ECONOMIST*	Pub. date
Fighting among blacks in Pietermartizburg	January 1988
Hendrickse, Allan, and questions about the general election / Group Areas Act	January 1988
Media, press, limits of freedom	January 1988
Sanctions, new study on	January 1988
Angola, and support for Unita guerrillas	February 1988
Apartheid, gradual erosion of in hospitals / housing / education	February 1988
Bills on residential areas / car bomb outside rugby stadium / ANC policy	February 1988
Black townships, violence / rethinking of tactics	February 1988
Botha, PW, banning of 17 black organisations	February 1988
Stock markets, slump in gold stocks	February 1988
Angola, and proposal for "non-aligned" government coalition / armed forces in	March 1988
Elections, parliamentary by-elections, Conservative victory / dilemma for NP	March 1988
Government further curbs on democracy, summary	March 1988
Religion, government – church discord / Dutch Reformed Church stance on apartheid	March 1988
United Nations budget contribution arrears	March 1988
ANC, alleged involvement in violence against	April 1988
Botha, PW, comparison with Gorbachev, Mikhail / programme of reforms	April 1988
Japan, and trade with apartheid	April 1988
Liberal Party, activities of ex-members / death of Paton, Alan	April 1988
Namibia, and independence from / importance to Angola	April 1988

Race relations, De Beers call for new South African constitution / black equality	April 1988
Trade unions, Cosatu strike	April 1988
Afrikaners, as supporters of ANC / terrorists	May 1988
Angola, and possible involvement in following ending of war	May 1988
Antarctica and mining, talks on international convention	May 1988
Disease, AIDS, unwillingness to undertake research / need for statistics and openness	May 1988
Literature, censorship	May 1988
Politics, Promotion of Orderly Politics Bill and restrictions on foreign money for political groups	May 1988
USSR, new approach to / academic and diplomatic contacts	May 1988
Angola, and diminished influence over UNITA	June 1988
Election campaign launch / renewal of state of emergency	June 1988
Mozambique, and improved relations / plan to restore Cahora Bassa Dam	June 1988
USA, and Jackson, Jesse request for Democratic Party platform commitment on /house sanctions bill	June 1988
Angola, negotiations in Egypt	July 1988
Opposition to conscription / acceptance of Angola / Namibia peace plan	July 1988
Preview of municipal elections / black leaders' refusal to serve on national council	July 1988
Sanctions, new USA bill /new tariff controls	July 1988
Stock markets, possible penalties for USA citizens holding South African shares	July 1988
Angola, ceasefire announcement, possible snags	August 1988
Angola / Namibia, and departure proposal	August 1988
Angola, and withdrawal from	September 1988
Angola government / UNITA relations and	September 1988
Diamonds, India trade and	September 1988

Economy, gold / foreign-currency reserves	September 1988
Elections, preview	September 1988
Election preview / questions on release of Mandela, Nelson and power – sharing	October 1988
Elections, municipal, black / white vote	October 1988
Government crackdown on political activity	October 1988
Investment abroad to guard against sanctions	October 1988
Labour Party blocking of Group Areas Act / other bills	October 1988
Media, newspapers, probable closure of Weekly Mail / launch of Vrye Weekblad	October 1988
Mozambique, and relations / talks	October 1988
Possible Southern Africa summit	October 1988
Religion, apartheid and	October 1988
Resumption of Angola talks	October 1988
Death sentences, commuting of 13 / treason convictions	November 1988
Economy, problems / frozen foreign debt / current account	November 1988
Economy, state of / black economy	November 1988
Elections, municipal, results / possible effects on Heunis, Chris	November 1988
Namibia, and withdrawal agreement	November 1988
Pan Africanist Congress, history / revival of	November 1988
"whites only" signs / white man killing of blacks	November 1988
Gold, effects of new discoveries on	December 1988
Namibia / Angola double withdrawal deal, cancellation of signing of	December 1988
Namibia / Angola peace deal, signing of	December 1988
Release of Mothopeng, Zephania and Sisulu, Zwelakhe / question of Mandela, Nelson release	December 1988

POLITICAL & ECONOMIC EVENTS OVER THE PERIOD STUDIED AS REPORTED IN *THE ECONOMIST*	Pub. date
Afrikaner Resistance Movement, incidents involving Terre Blanche, Eugene and Allan, Jani at Paardekraal and Voortrekker Monuments / Pretoria massacre	January 1989
Apartheid, Botha, PW reforms / inevitability of further government concessions	January 1989
Government, Botha, PW mild stroke / possible successors	January 1989
Angola, and former support for UNITA	February 1989
Economy, cut in foreign debt / cost of international sanctions	February 1989
Government, de Klerk, FW as likely next president / Botha, PW resignation	February 1989
Government, presidency, questions of elections / candidates to succeed Botha, PW	February 1989
"Mandela United Football Club", democratic movement criticism of	February 1989
"Mandela United Football Club", abduction of youths / alleged murder of Mokhetsi, Stompie and	February 1989
Namibia, and withdrawal of troops / Namibia's transition to independence and	February 1989
ANC, National Party attitude softening	March 1989
Government, Botha, PW plans to resume presidency / question of election	March 1989
National Party calls for resignation of Botha, PW / question of mixed – race voting	March 1989
Retail business, black boycott of white shops in Carltonville / purchasing power	March 1989
Namibian peace settlement and, fighting with Swapo guerillas	April 1989
Namibia peace agreement / Swapo and	April 1989
Politics, Democratic Party, launch / belief in universal suffrage	April 1989
UK, and attempted arms deal with Ulster Resistance / arrest of diplomat in Paris	April 1989
USA pension funds, and companies' support for	April 1989
Business, "black empowerment" / white ownership	June 1989

Education, Soweto schools, state of / overcrowding	June 1989
Government, de Klerk, FW visit to Europe, Western / reform promises / profile	June 1989
Mozambique relations	June 1989
Sport, running, black domination of Comrades race / marathon	June 1989
Debts, exploitation of	July 1989
Effect of improved railways on neighbours	July 1989
Ivory trade ban and protection of the elephant	July 1989
Law, restrictions on blacks	July 1989
Mozambique peace talks	July 1989
Oppenheimer family, three-page report	July 1989
Politics, PW meeting with Mandela, Nelson / Nationalist Party popularity/ talks on new constitution	July 1989
Politics, Broederbond, resurgence under de Klerk, FW / National Party five-year "Plan of Action" and / role of president	July 1989
Politics, Mandela, Nelson, birthday celebration / election, black protests / boycott against / Democratic Party and	July 1989
Politics, National Party election manifesto and dividing and sharing of power between racial groups	July 1989
Bond markets, high-yielding government bonds	July 1989
Elections, issues / Mass Democratic Movement campaign	August 1989
Government, Botha, PW resignation, effect on polls / record as president / de Klerk, FW new National Party leader, prospects	August 1989
Namibia, election issues and	August 1989
Sport, cricket, England Test team members and	August 1989
Sport, cricket, UK rebel tour	August 1989
De Klerk, FW, presidential speech	September 1989
Elections, de Klerk, FW pre-election talks with foreigners / preview of coloured and Indian voting	September 1989
Elections, opinion polls / prospects	September 1989

Elections, preview	September 1989
Elections, results / question of power-sharing	September 1989
African National Congress, government contact with	October 1989
Apartheid, Commonwealth commumique, Kuala Lumpur and	October 1989
Banks and banking, debt rescheduling	October 1989
Banks and banking, reserve bank debt rescheduling	October 1989
Broederbond, influence / proposals on reform	October 1989
Decrease in executions	October 1989
Economy, debt rescheduling	October 1989
Economy, sanctions and	October 1989
Economy / government, need for pluralism and decentralisation	October 1989
Politics, relationship between ANC and Communist Party	October 1989
Politics, start of dialogue with blacks	October 1989
African National Congress / rival black groups	November 1989
Death squads, allegations of police connections / corroboration	November 1989
Namibia, and allegation of Swapo incursion	November 1989
Pan–Africanist Movement, launch of	December 1989

POLITICAL & ECONOMIC EVENTS OVER THE PERIOD STUDIED AS REPORTED IN *THE ECONOMIST*	Pub. date
ANC and negotiations	January 1990
Black schools failure rate	January 1990
De Klerk and reform	January 1990
Market focus, stocks and bonds	January 1990
Possible release of Nelson Mandela	January 1990
Road to democracy	January 1990
Apartheid laws	February 1990
Economy after removal of sanctions	February 1990
Mandela's release	February 1990
Mandela's release, opinion	February 1990
Sanctions, Mrs Thatcher and the European Community	February 1990
Surrender of white power, opinion	February 1990
White political reaction to Mandela's release	February 1990
Collapse of black states	March 1990
ANC / government talks, opinion	April 1990
De Klerk – Mandela talks	April 1990
First government talks with ANC	April 1990
Death / torture squads	May 1990
Prospects for black rule	May 1990
Sanctions, de Klerk's and Mandela's interests	May 1990
EC relaxation of sanctions	June 1990
Mandela visit to United States	June 1990
Market focus, gold market, falling price	June 1990
Natal violence	June 1990
Political situation	June 1990
British historical reaction to situation	July 1990
Internal politics	July 1990
Internal power struggles	July 1990

Black township violence	August 1990
Coalition hopes	August 1990
Communist Party	August 1990
Sanctions, Dutch plan	August 1990
Suspension of armed struggle	August 1990
Violence in black townships	August 1990
Control of platinum and chromite production	September 1990
De Klerk and Mandela meeting	September 1990
De Klerk visit to United States	September 1990
Township violence	September 1990
Winnie Mandela prosecution	September 1990
Black in-fighting	October 1990
Shaping black politics	October 1990
ANC as future government	November 1990
Constitutional negotiations	November 1990
Constitutional talks, lack of	November 1990
Economic future	November 1990
Economy, future under black rule	November 1990
End of apartheid, relations with neighbours	November 1990
Peasants	November 1990
Survey	November 1990
White apprehensions about black rule	November 1990
Apartheid talks stalled	December 1990
Homelands	December 1990
Reintegration of homelands	December 1990
Sanctions against	December 1990

POLITICAL & ECONOMIC EVENTS OVER THE PERIOD STUDIED AS REPORTED IN *THE ECONOMIST*	Pub. date
Talks on new constitution stalled	January 1991
Violence and uncertainty	January 1991
De Klerk promises to end apartheid	February 1991
Winnie Mandela's trial raises doubt about ANC	February 1991
Internal situation	March 1991
Plans to change apartheid land laws	March 1991
Possible return to Olympic competition	March 1991
ANC ultimatum to De Klerk	April 1991
EC sanctions on iron, steel and gold lifted	April 1991
Gold mines closings	April 1991
Violence in black townships	April 1991
Zulu weapons law under threat	April 1991
ANC-government compromise	May 1991
Lesotho, military coup	May 1991
Squatters murdered by Zulus	May 1991
Tribal rivalries	May 1991
Winnie Mandela sentencing	May 1991
ANC, new leadership	June 1991
Coloured MPs join National Party	June 1991
Gradual dismantling of apartheid	June 1991
Population Registration Act repeal	June 1991
America's trade embargo ended	July 1991
ANC, first conference held at home	July 1991
ANC, new executive	July 1991
Investment after sanctions	July 1991
Police, financing Inkatha	July 1991
Rothman's July race, ANC conference	July 1991
Afrikaner whites blame De Klerk for increasing violence	August 1991

ANC-Inkatha violence, problem of	August 1991
Black capitalism	August 1991
Payment to Inkatha, De Klerk's denial	August 1991
Massacre by unknown gunmen	September 1991
Rejection of the new constitution	September 1991
Commonwealth meeting participation	October 1991
Commonwealth summit, no movement	October 1991
New constitution, possible first meeting	October 1991
Difficulties of democratisation	November 1991
Formation of Patriotic Front	November 1991
Killings at gold mine	November 1991
Communist Party	December 1991
Possibility of talks between ANC and PAC	December 1991

POLITICAL & ECONOMIC EVENTS OVER THE PERIOD STUDIED AS REPORTED IN *THE ECONOMIST*	Pub. date
African National Congress, constitutional demands	January 1992
Afrikaner homeland	February 1992
Bankorp / ASBSA merger	February 1992
Confusion in process of democratisation	February 1992
Election, Conservative Party's win	February 1992
Optimism about De Klerk	February 1992
Possibility of a coup against De Klerk	February 1992
Prospects of economic equality	February 1992
Split conservatives	February 1992
Referendum	March 1992
Reform referendum	March 1992
Results of referendum	March 1992
Suggestions for new constitution and government	March 1992
EC ban on oil sales lifted	April 1992
Future	April 1992
Mandela, Winnie, new criminal allegations	April 1992
Scandals undermining reform	May 1992
African National Congress demonstrations against government	June 1992
After apartheid	June 1992
Boipatong massacre	June 1992
Boipatong massacre and aftermath	June 1992
Water imports from Lesotho projects	June 1992
African National Congress and FW De Klerk	July 1992
Afrikaners	August 1992
Mass action, government in action	August 1992
Strikes	August 1992
Arms control	September 1992
Ciskei massacre	September 1992

Homelands unrest	September 1992
Buthelezi, Mangosuthu secession from talks	October 1992
De Klerk, FW, presidency	October 1992
Government devolution	October 1992
Natal, profile of Harry Gwala	October 1992
Dirty tricks accusations	November 1992
Namibia, impact of majority rule	November 1992
Peace negotiations	November 1992
Black radicals	December 1992
ANC / government talks, multi-racial elections	December 1992
Extremist violence	December 1992
Lost City resort, opening	December 1992
Military purge by government	December 1992

POLITICAL & ECONOMIC EVENTS OVER THE PERIOD STUDIED AS REPORTED IN *THE ECONOMIST*	Pub. date
ANC/government talks	January 1993
Long-distance runners	January 1993
New bilateral talks with ANC	January 1993
Stockmarket, JSE Industrial Index composition, indicators	January 1993
Constitutional changes	February 1993
Future government, power-sharing	February 1993
Talks to end apartheid, proposals	February 1993
Constitution talks resumption	March 1993
Economy, post-apartheid problems and challenges	March 1993
Negotiations, role of IFP and Chief Buthelezi	March 1993
Nuclear bomb	March 1993
Party negotiations and past strife	March 1993
Past nuclear bombs disclosed	March 1993
Prospects for peace	March 1993
Race relations and standards after apartheid	March 1993
Survey	March 1993
Black homeland incorporation plans	April 1993
Hani, Chris, assassination	April 1993
Extremists and Chris Hani death	April 1993
Funeral of murdered communist leader	April 1993
Hani, Chris national day of mourning	April 1993
Homelands	April 1993
Political future after Chris Hani assassination	April 1993
Transkei isolation	April 1993
Afrikaners homeland proposal	May 1993
ANC leaders assassination plots	May 1993
Companies, unbundling	May 1993
Pan Africanist Congress	May 1993

Political leaders' deaths	May 1993
School disorder, De Klerk/Mandela meeting	May 1993
Whites' consolidation and Volksfront	May 1993
Future	June 1993
Mandela/Buthelezi meeting	June 1993
Nationalist parties	June 1993
Afrikaner attacks on constitutional talks	July 1993
Bloodshed, church killing	July 1993
Constitutional compromises	July 1993
Draft constitution	July 1993
Inkatha/Conservative boycott of talks	July 1993
New draft constitution	July 1993
Race relations and politics	July 1993
Reform proposals	July 1993
Regional government proposals	July 1993
ANC beatings allegations	August 1993
ANC under scrutiny	August 1993
De Klerk/Mandela disagreements	August 1993
Political killings increase	August 1993
Unemployment estimates	August 1993
White votes	August 1993
Multiparty transitional body	September 1993
Transitional executive council	September 1993
Transitional pre-election council	September 1993
Afrikaner dispute	October 1993
Economic sanctions lifted	October 1993
Hani, Chris, murder, two convicted	October 1993
Multiparty talks	October 1993
Rightwingers trial	October 1993
Draft constitution, final details	November 1993

Constitution, final draft	November 1993
Constitution signed, concessions	November 1993
Police force	November 1993
Afrikaner gathering, Pretoria	December 1993
AVF rival transitional government	December 1993
Business and industry, post–apartheid	December 1993
Declining tribalism, counter to world trends	December 1993
Election preparation and peacekeeping	December 1993
Election, transition to democracy	December 1993
Transitional executive council star	December 1993

POLITICAL & ECONOMIC EVENTS OVER THE PERIOD STUDIED AS REPORTED IN *THE ECONOMIST*	Pub. date
Constitutional talks	January 1994
Election and Zulus	January 1994
Murder investigation	January 1994
Political violence	January 1994
Political violence tally	January 1994
Relations with Tanzania	January 1994
Zulu demonstrations	January 1994
ANC and election campaign	February 1994
Apartheid, cost of undoing	February 1994
Buthelezi, Mangosuthu, election boycott	February 1994
Election campaign, ANC manifesto launch	February 1994
Election registrations	February 1994
Voter registration drive	February 1994
Bophuthatswana uprising	February 1994
IFP, possible registration	February 1994
Political parties	February 1994
Political parties and election	February 1994
Political past	February 1994
Pre-election instability	February 1994
Relations with black Africa	February 1994
Tourism	February 1994
Train accident	February 1994
Zulu rivarly	April 1994
KwaZulu-Natal state of emergency	April 1994
Election stalemate, efforts to break	April 1994
IFP, end of election boycott	April 1994
Johannesburg killings	April 1994
Johannesburg killings chart	April 1994

Election, first non–racial	April 1994
Election	April 1994
Election (maps and charts)	April 1994
Election and KwaZulu-Natal	April 1994
KwaZulu-Natal, elections and political violence	April 1994
Stock market, market focus	April 1994
Election results	May 1994
Election, ANC victory	May 1994
Mandela, Nelson, new cabinet	May 1994
Presidential inauguration	May 1994
Problems facing new government	May 1994
Brewing industry, operating practices	May 1994
Mandela, Nelson, first state of the nation speech	May 1994
Land, problem for government	May 1994
Land, restitution and distribution to blacks	May 1994
Political amnesty, mechanisms for granting	May 1994
Economy, presentation of budget	May 1994
Human-rights commission promise	May 1994
ANC, alleged cover-up of Zulu killings	May 1994
Israel, alleged Mossad involvement in businessman's murder	May 1994
Labour unrest	May 1994
Liebenberg, Chris, new finance minister	May 1994
Black businessmen	August 1994
Cricket	August 1994
Defence, manpower and budget debate	August 1994
Mining industry, need for reform	August 1994
Languages	September 1994
Major, John, visit	September 1994
Mining wage settlement	September 1994
Monthly inflation rise	September 1994

American student murder, black youths imprisonment	September 1994
ANC and open government	September 1994
Buthelezi, Mangosuthu in television fight	September 1994
Credit rating increases	September 1994
Government, criticism of parliamentary pay	September 1994
KwaZulu-Natal, political tensions	September 1994
Sovereign risk rating, granting	September 1994
Government, ANC weakness in governing	November 1994
Rugby, new national anthem	November 1994
State enterprises, possible privatisation	November 1994
Wildlife conference, lifting of white rhino export ban	November 1994
Black identity and relations with whites	December 1994
Elections, Nelson Mandela and ANC victory	December 1994
Europe, trade and concessions	December 1994
First international bond launch	December 1994

POLITICAL & ECONOMIC EVENTS OVER THE PERIOD STUDIED AS REPORTED IN *THE ECONOMIST*	Pub. date
ANC/National Party conflict over police indemnities	January 1995
Housing, obstacles to government policy	January 1995
Police, revoking of prosecution-immunity	January 1995
Schools' desegregation	January 1995
Schools, models and integration	January 1995
Boesak, Alan, corruption allegations	February 1995
Mandela, Winnie, outspokenness and Women's League resignations	February 1995
Parliament, Inkatha walkout and threat of violence	February 1995
Police, appointment of new chief	February 1995
Political controversies	February 1995
Politics, Inkatha withdrawl from parliament	February 1995
Taiwanese links, stumbling block for Chinese relations	February 1995
Truth commission, parliamentary debate on role	February 1995
Two-tier exchange rate, fraud problems	February 1995
Investor-friendly budget	March 1995
Queen's visit	March 1995
Ubuntu, management theory	March 1995
Zulu rivalries and restored monarchy suggestion	March 1995
Boesak, Alan, corruption exoneration	April 1995
Mandela, Winnie, dismissal from cabinet and political future	April 1995
Government, Winnie Mandela sacking	April 1995
Inkatha party, assembly-walkout threat	April 1995
Inkatha party, boycott threat	April 1995
Inkatha party, death-squads allegations	April 1995
Mandela, Winnie ministerial resignation	April 1995
Race relations, possible introduction of affirmative action policies	April 1995
Universities, changing racial composition	April 1995
Economic growth, need for end of industrial protectionism	May 1995

Education, financing of black schools	May 1995
Foreign direct investment, cautious growth	May 1995
Gold mining, decline	May 1995
KwaZulu–Natal , dispute with government	May 1995
KwaZulu–Natal, funding-cut threat	May 1995
KwaZulu–Natal, increasing political violence	May 1995
Pietersburg, profile of town post-apartheid	May 1995
Political future after Mandela	May 1995
Political relations, Nelson Mandela and Chief Buthelezi	May 1995
Privatisation, tentative steps	May 1995
Race and society, move towards multi-culturalism	May 1995
Relations with southern African countries	May 1995
Rugby, push to involve black majority	May 1995
Central bank independence, threats	June 1995
Exchange controls and capital inflows	June 1995
Land, restitution and distribution to blacks	June 1995
Languages, multiplicity	June 1995
Mandela, Nelson, Inkatha – demonstration killings admission	June 1995
Nthato Motlana's business empire, face value	June 1995
Racial integration and forthcoming council elections	June 1995
African Development Bank membership, continued postponement	July 1995
Armed forces, purchase of new battleships	July 1995
Arms trade, political control	July 1995
Armscor illegal weapons sale	July 1995
Banking, reaching the unbanked	July 1995
Crime and prevention	July 1995
Employers/unions, industrial relations deal	July 1995
Labour relations, new bill	July 1995
Mercenary ex-servicemen	July 1995
Rugby World Cup champions	July 1995

Theatre, post-apartheid problems	July 1995
Armed forces, defence cuts and army integration plan	August 1995
Business, conglomerates and demerges	August 1995
Foreign investment banks, influx	August 1995
Gambling, possible economic effects of legislation	August 1995
Mandela, Nelson, dress sense	August 1995
Trade liberalisation onus on Government	August 1995
Education system, reform	August 1995
Foreign – exchange controls	September 1995
KwaZulu-Natal, political murders	September 1995
KwaZulu Natal, political violence	September 1995
Parliament relocation debate	September 1995
Solar power possibilities	September 1995
Southern African Development Community's economic powerhouse	September 1995
Constitution, draft, publication	October 1995
Elections, forthcoming municipal	October 1995
Industry, competition policy, positive aspects	October 1995
World Bank loan offers, dissent	October 1995
Central bank independence, threats	November 1995
Elections, local	November 1995
Elections local, ANC endorsement	November 1995
Elections, local, ANC victories	November 1995
Malan, Magnus, arrest	November 1995
Nigeria, internal criticism over Saro-Wiwa execution	November 1995
Sasol, reincarnation	November 1995
Stock exchange big bang	November 1995
Defence, former minister and officers on murder charges	December 1995
Crime in Johannesburg	December 1995
Education, universities and race relations	December 1995
National Party's insult to Nelson Mandela	December 1995

Novels, apartheid legacy	December 1995
Privatisation, slow progress	December 1995
Sport, black involvement	December 1995
White minority, attitudes under black leadership	December 1995
Witchcraft, resurgence of witch-burning	December 1995

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KwaZulu Natal, political murder in	January 1996
Constitution, South Africa's new	January 1996
Politics, National Party dreams	January 1996
Sport, South Africa's footballers	February 1996
Truth Commission	February 1996
Suburbs, blacks flee to	February 1996
Education, integrating schools	March 1996
Politics, who would run South Africa?	March 1996
KwaZulu Natal, killings in	March 1996
Black business bid for Johnic group	April 1996
Coloureds, continued discrimination	April 1996
Massacre correction	April 1996
Ramaphosa, Cyril, exit from politics	April 1996
Rand low	April 1996
Reconstruction and development programme, abandonment	April 1996
Truth and Reconciliation Commission hearings, opening	April 1996
Truth Commission, first sitting	April 1996
Truth Commission, effort at reconciliation	April 1996
Botha, Pik, departure from politics	May 1996
Constitution, protest at draft	May 1996
Mining companies' interest in West Africa	May 1996
Mozambique, investment in infrastructure and industry	May 1996
National Party coalition desertion	May 1996
National Party resignation from government	May 1996
National Party's pull-out	May 1996
Rand's further slide, lack of cause	May 1996
Strike over constitution	May 1996
Banking, mobile and fingerprint identification	June 1996

Banking, Standard bank profile	June 1996
Black Americans' homecoming	June 1996
Economic reform plans	June 1996
KwaZulu-Natal, prospects for peace	June 1996
Tutu, Archbishop Desmond, retirement	June 1996
White support for Inkatha	June 1996
European Union, trade deal, obstacles	July 1996
KwaZulu–Natal elections, Inkatha victory	July 1996
KwaZulu–Natal provincial elections, rural/urban divide	July 1996
Mandela, Nelson, British visit	July 1996
ANC, bribery allegations and party donations	August 1996
Apartheid apology by FW de Klerk	August 1996
Asian investment	August 1996
Crime, reform of police force	August 1996
Bribes scandal	August 1996
de Kock, Eugene, murder convictions	August 1996
Airlines, competition for routes	September 1996
de Kock, Eugene, presidential allegations	September 1996
Mandela, Nelson, relationship with Graca Machel	September 1996
Sub-Saharan Africa, model for future	September 1996
Truth and Reconciliation Commission, amnesty's power limitations	September 1996
Zulus, make peace	October 1996
Politics, South Africans growing anxious about their future after Mandela: editorial	October 1996
Bonding of South Africa's blacks	October 1996
Apartheid's defenders confess	October 1996
Housing, dearth of	November 1996
ANC centralisers	December 1996

POLITICAL & ECONOMIC EVENTS OVER THE PERIOD STUDIED AS REPORTED IN *THE ECONOMIST*	Pub. date
Angola, role as peace broker	January 1997
Bombings, Boer Attack Troops, member's rearrest	January 1997
Political crimes, amnesty extensions	January 1997
Servant/employer relationship post apartheid	January 1997
Syria, arms sales	January 1997
Syria, US objection to weapon sales	January 1997
Biko, Steve, killers' amnesty plea	February 1997
Biko, Steve, murder confessions	February 1997
Brewing industry, challenge to industry giant	February 1997
Cape Town, focus of white migration	February 1997
Police, Lifeline project	February 1997
Political parties, potential opposition alliances	February 1997
Black run business, growing success	March 1997
Advertising, political correctness	March 1997
Economic turnaround	March 1997
Economy, abolition of currency controls and regional trade barriers call	March 1997
Zulu nationalist march in Soweto	March 1997
Mandela and Mbeki	April 1997
Southern Africa: whose game parks?	May 1997
Politics, indestructible Winnie Mandela	May 1997
South African diplomacy	May 1997
Politics, Nats split	May 1997
South Africa's new policeman	May 1997
Southern Africa's economical revival	June 1997
AIDS, increase and prevention	June 1997
Exchange controls, possible liberalisation	July 1977
Gold-mining industry's decline	July 1977
Afrikaner's emigration to North Africa	August 1997

Botha, PW, marriage rumour	August 1997
Commission,Chris Hani's killers' amnesty appeal	August 1997
De Klerk, FW, retirement from party politics	August 1997
De Klerk, FW, resignation from politics	August 1997
Hani, Chris, murderers' amnesty appeal	August 1997
Olympic bid and racial differences	August 1997
Politics, manoeuvering to succeed the president	August 1997
Gold mining industry, need for overhaul	August 1997
McDonald's effort to enter market	August 1997
Madikizela-Mandela, Winnie, new allegations	August 1997
Insurance companies, stockmarket interests	August 1997
National Party, leadership appointment	August 1997
Society, crime prevention with economic growth	August 1997
Politics aid by racial South African party	October 1997
Apartheid men tell their story	October 1997
South Africa's wealth gap	October 1997
White South Africa awaits Mbeki	November 1997
The truth about Winnie Mandela	November 1997
A brave yet a troubled country	December 1997
Nelson Mandela is about to step down as leader of the ANC: editorial	December 1997
South Africa's new men	December 1997

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Sharing South Africa's wealth	January 1998
Truth Commission	January 1998
Politics, parliamentary yawn	February 1998
Toiling in the Cape's vineyards	February 1998
Local squander in South Africa	February 1998
Sport, South Africa's all white rugby	April 1998
Botha, PW, unrepented	April 1998
South Africa's taxi wars	May 1998
White flight from South Africa	June 1998

APPENDIX 2

Shares selected from the Financial and Industrial sectors on the JSE to represent the FINDI30 (F & I Index)

SECTOR	NUMBER OF SHARES	SHARE NAME	JSE CODE
FINANCIAL			
Banks & financial services	8	BOE FIDELITY NEDCOR SAAMBOU SASFIN STANBIC ABSA AD CORP	BOE FDL NED SBO SFN SBC ASA ADR
Insurance	7	CUSAF FEDSURE GUARDIAN LIBERTY METLIFE SANTAM LIBERTY HOLD	CUA FDS GAR LLA MET SNT LBH
Investment trusts	1	GENSA	GBL
Property	4	RMPPROP AMAPROP SABLE MAWENZI RESOURCES	RMP ARO SBL MWZ
Property trusts	3	CBD FUND UMDONI PRIMA	CBD UMN PRM
INDUSTRIAL			
Industrial holding	9	AMIC AVI CGSMITH HOLD SAFREN PLATE GL DUNLOP M&R HOLD METKOR CHARTER	AMI AVI CGS SFR PGS DNL MUR MTK CHR
Beverages, hotels & leisure	2	KERSAF SA BREWS	KER SAB

SECTOR	NUMBER OF SHARES	SHARE NAME	JSE CODE
Building & construction	1	PP CEMENT	PPC
Chemicals & oil	3	SASOL ENGEN AECI	SOL EGN AFE
Electronics	1	POWTECH	POW
Engineering	1	AFROX	AFX
FOOD	6	HLH I&J TIG. OATS TONGAAT CGSMITH FOODS CADSWEP	HLH IRV TIG TNT CSF CAS
Furniture, household & allied	1	ELERINE	ELH
Motor	1	TOYOTA	TOY
Packaging & printing	1	NAMPAK SAPPI	NPK SAP
Steel & allied	1	HIVELD	HVL
Stores	6	PICK 'N PAY WOOLTRU MC CARTHY SHOPRITE EDGARS PEP	PIK WLO MCR SHP EDS PEP

APPENDIX 3

The 512 equations that were regressed for every time period in order to find the best subset LFM for that period using the Adjusted R^2 statistic as the selection criterion

EPFINIIND = B0
EPFINIIND = B0 + B1*RPDJ
EPFINIIND = B0 + B2*RPDGOLD
EPFINIIND = B0 + B3*RTSD
EPFINIIND = B0 + B4*RPINT
EPFINIIND = B0 + B5*RPIFDIV
EPFINIIND = B0 + B6*RPVOL
EPFINIIND = B0 + B7*RPCRUDE
EPFINIIND = B0 + B8*RPSACB1
EPFINIIND = B0 + B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD
EPFINIIND = B0 + B1*RPDJ +B3*RTSD
EPFINIIND = B0 + B1*RPDJ +B4*RPINT
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV
EPFINIIND = B0 + B1*RPDJ +B6*RPVOL
EPFINIIND = B0 + B1*RPDJ +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIV
EPFINIIND = B0 + B2*RPDGOLD +B6*RPVOL
EPFINIIND = B0 + B2*RPDGOLD +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B9*RPCPI2
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EPFINIIND = B0 +B3*RTSD +B6*RPVOL
EPFINIIND = B0 +B3*RTSD +B7*RPCRUDE
EPFINIIND = B0 +B3*RTSD +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B9*RPCPI2
EPFINIIND = B0 +B4*RPINT +B5*RPIFDIV
EPFINIIND = B0 +B4*RPINT +B6*RPVOL
EPFINIIND = B0 +B4*RPINT +B7*RPCRUDE
EPFINIIND = B0 +B4*RPINT +B8*RPSACB1
EPFINIIND = B0 +B4*RPINT + B*RPCPI
EPFINIIND = B0 +B5*RPIFDIV +B6*RPVOL
EPFINIIND = B0 +B5*RPIFDIV +B7*RPCRUDE
EPFINIIND = B0 +B5*RPIFDIV +B8*RPSACB1
EPFINIIND = B0 +B5*RPIFDIV +B9*RPCPI2
EPFINIIND = B0 +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B3*RTSD
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B4*RPINT
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B5*RPIFDIV
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B6*RPVOL
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EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B4*RPINT
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EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B7*RPCRUDE

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EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B6*RPVOL
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV +B6*RPVOL
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B4*RPINT
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B5*RPIFDIV
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B6*RPVOL
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B5*RPIFDIV
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B6*RPVOL
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIVD +B6*RPVOL
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIVD +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIVD +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIVD +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B5*RPIFDIV
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B6*RPVOL
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B7*RPCRUDE
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B6*RPVOL
EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B7*RPCRUDE
EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 +B3*RTSD +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B4*RPINT +B5*RPIFDIV +B6*RPVOL
EPFINIIND = B0 +B4*RPINT +B5*RPIFDIV +B7*RPCRUDE
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EPFINIIND = B0 +B4*RPINT +B6*RPVOL +B7*RPCRUDE
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EPFINIIND = B0 +B4*RPINT +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 +B4*RPINT +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B5*RPIFDIV +B6*RPVOL +B7*RPCRUDE
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EPFINIIND = B0 +B5*RPIFDIV +B6*RPVOL +B9*RPCPI2
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EPFINIIND = B0 +B5*RPIFDIV +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B6*RPVOL +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 +B6*RPVOL +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 +B6*RPVOL +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B7*RPCRUDE +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B3*RTSD +B4*RPINT
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B3*RTSD +B5*RPIFDIV
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B3*RTSD +B6*RPVOL
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B3*RTSD +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B3*RTSD +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B3*RTSD +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B4*RPINT +B5*RPIFDIV
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B4*RPINT +B6*RPVOL
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B4*RPINT +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B4*RPINT +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B4*RPINT +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B5*RPIFDIV +B6*RPVOL
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B5*RPIFDIV +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B5*RPIFDIV +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B5*RPIFDIV +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD + RPPRVOL +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B7*RPCRUDE + RPSACD1
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ + B2*RPDGOLD +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B4*RPINT +B5*RPIFDIV
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B4*RPINT +B6*RPVOL
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B4*RPINT +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B4*RPINT +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B4*RPINT +B9*RPCPI2
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EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B5*RPIFDIV +B8*RPSACB1
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EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B3*RTSD +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B5*RPIFDIV +B6*RPVOL
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B5*RPIFDIV +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B5*RPIFDIV +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B5*RPIFDIV +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B7*RPCRUDE +RPSACB1

EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B4*RPINT +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B5*RPIFDIV + RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B6*RPVOL +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 + B1*RPDJ +B6*RPVOL +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B6*RPVOL +B7*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B1*RPDJ +B7*RPCRUDE +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B4*RPINT +B5*RPIFDIV
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B4*RPINT +B6*RPVOL
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B4*RPINT +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B4*RPINT +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B4*RPINT +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B5*RPIFDIV +B6*RPVOL
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B5*RPIFDIV +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B5*RPIFDIV +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B5*RPIFDIV +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B6*RPVOL +B9*RPCPI2
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EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B3*RTSD +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B5*RPIFDIV +B6*RPVOL
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B5*RPIFDIV +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B5*RPIFDIV +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B5*RPIFDIV +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B7*RPCRUDE +RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B4*RPINT +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIV +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIV +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIV +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIV +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIV +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B5*RPIFDIV +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B6*RPVOL +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 + B2*RPDGOLD +B6*RPVOL +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B6*RPVOL +B7*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 + B2*RPDGOLD +B7*RPCRUDE +RPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B5*RPIFDIV +B6*RPVOL
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B5*RPIFDIV +B7*RPCRUDE
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B5*RPIFDIV +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B5*RPIFDIV +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B4*RPINT +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B6*RPVOL +B7*RPCRUDE

EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B6*RPVOL +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B7*RPCRUDE +B8*RPSACB1
EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B7*RPCRUDE +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B5*RPIFDIV +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B6*RPVOL +B7*RPCRUDE +B8*RPSACB1
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EPFINIIND = B0 +B3*RTSD +B6*RPVOL +B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B3*RTSD +B7*RPCRUDE + B8*RPRPSACB1 +B9*RPCPI2
EPFINIIND = B0 +B4*RPINT +B5*RPIFDIVD + B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0 +B4*RPINT +B5*RPIFDIVD + B6*RPVOL +B8*RPSACB1
EPFINIIND = B0 +B4*RPINT +B5*RPIFDIVD + B6*RPVOL +B9*RPCPI2
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EPFINIIND = B0 +B4*RPINT +B6*RPVOL +B7*RPCRUDE +B8*RPSACB1
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EPFINIIND = B0 +B5*RPIFDIV +B6*RPVOL +B7*RPCRUDE +B8*RPSACB1
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EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B4*RPINT + B5*RPIFDIV
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B4*RPINT + B6*RPVOL
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EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B4*RPINT + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B5*RPIFDIV + B6*RPVOL
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B5*RPIFDIV + B7*RPCRUDE
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EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B6*RPVOL + B7*RPCRUDE
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B6*RPVOL + B8*RPSACB1
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B6*RPVOL + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B7*RPCRUDE + B8*RPSACB1
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B7*RPCRUDE + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B3*RTSD + B8*RPSACB1 + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B4*RPINT + B5*RPIFDIV + B6*RPVOL
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B4*RPINT + B5*RPIFDIV + B7*RPCRUDE
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B4*RPINT + B5*RPIFDIV + B8*RPSACB1
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EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B4*RPINT + B6*RPVOL + B7*RPCRUDE
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EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B4*RPINT + B6*RPVOL + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B4*RPINT + B7*RPCRUDE + B8*RPSACB1
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B4*RPINT + B7*RPCRUDE + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B4*RPINT + B8*RPSACB1 + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B5*RPIFDIV + B6*RPVOL + B7*RPCRUDE
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EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B5*RPIFDIV +B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B5*RPIFDIV + B7*RPCRUDE + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B5*RPIFDIV + B8*RPSACB1 + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B6*RPVOL + B7*RPCRUDE + B8*RPSACB1
EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B6*RPVOL + B7*RPCRUDE + B9*RPCPI2
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EPFINIIND = B0+B1*RPDJ + B2*RPDGOLD + B7*RPCRUDE + B8*RPSACB1 + B9*RPCPI2
EPFINIIND = B0+B1*RPDJ + B3*RTSD + B4*RPINT + B5*RPIFDIV + B6*RPVOL
EPFINIIND = B0+B1*RPDJ + B3*RTSD + B4*RPINT + B5*RPIFDIV + B7*RPCRUDE
EPFINIIND = B0+B1*RPDJ + B3*RTSD + B4*RPINT + B5*RPIFDIV + B8*RPSACB1
EPFINIIND = B0+B1*RPDJ + B3*RTSD + B4*RPINT + B5*RPIFDIV + B9*RPCPI2
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EPFINIIND = B0+B1*RPDJ + B3*RTSD + B5*RPIFDIV + B6*RPVOL + B7*RPCRUDE
EPFINIIND = B0+B1*RPDJ + B3*RTSD + B5*RPIFDIV + B6*RPVOL + B8*RPSACB1
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EPFINIIND = B0+B2*RPDGOLD + B3*RTSD + B4*RPINT + B5*RPIFDIV + B6*RPVOL
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EPFINIIND = B0+B2*RPDGOLD + B3*RTSD + B4*RPINT + B5*RPIFDIV + B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD + B3*RTSD + B4*RPINT + B6*RPVOL + B7*RPCRUDE
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EPFINIIND = B0+B2*RPDGOLD + B3*RTSD + B4*RPINT + B6*RPVOL + B9*RPCPI2
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EPFINIIND = B0+B2*RPDGOLD + B4*RPINT + B5*RPIFDIV + B6*RPVOL +B7*RPCRUDE
EPFINIIND = B0+B2*RPDGOLD + B4*RPINT + B5*RPIFDIV + B6*RPVOL + B8*RPSACB1

EPFINIIND = B0+B2*RPDGOLD + B4*RPINT + B5*RPIFDIV + B6*RPVOL + B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD + B4*RPINT +B5*RPIFDIV+B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B2*RPDGOLD + B4*RPINT + B5*RPIFDIV + B7*RPCRUDE +B9*RPCPI2
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EPFINIIND = B0+B2*RPDGOLD + B4*RPINT + B7*RPCRUDE + 8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD +B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B2*RPDGOLD + B5*RPIFDIV + B6*RPVOL + B7*RPCRUDE+B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD + B5*RPIFDIV + B6*RPVOL + B8*RPSACB1 +B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD + B5*RPIFDIV B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD + B6*RPVOL + B7*RPCRUDE + B8*RPSACB+B9*RPCPI2
EPFINIIND = B0+B3*RTSD + B4*RPINT + B5*RPIFDIV + B6*RPVOL + B7*RPCRUDE
EPFINIIND = B0+B3*RTSD + B4*RPINT + B5*RPIFDIV + B6*RPVOL + B8*RPSACB1
EPFINIIND = B0+B3*RTSD + B4*RPINT + B5*RPIFDIV + B6*RPVOL + B9*RPCPI2
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EPFINIIND = B0+B3*RTSD + B4*RPINT + B5*RPIFDIV + B7*RPCRUDE + B9*RPCPI2
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EPFINIIND = B0+B3*RTSD + B4*RPINT + B6*RPVOL + B7*RPCRUDE + B8*RPSACB1
EPFINIIND = B0+B3*RTSD + B4*RPINT + B6*RPVOL + B7*RPCRUDE + B9*RPCPI2
EPFINIIND = B0+B3*RTSD + B4*RPINT + B6*RPVOL + B8*RPSACB1 + B9*RPCPI2
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EPFINIIND = B0+B3*RTSD + B5*RPIFDIV + B6*RPVOL + B7*RPCRUDE + B8*RPSACB1
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EPFINIIND = B0+B3*RTSD + B6*RPVOL + B7*RPCRUDE + B8*RPSACB1 + B9*RPCPI2
EPFINIIND = B0+B4*RPINT + B5*RPIFDIV + B6*RPVOL + B7*RPCRUDE + B8*RPSACB1
EPFINIIND = B0+B4*RPINT + B5*RPIFDIV + B6*RPVOL + B7*RPCRUDE + B9*RPCPI2
EPFINIIND = B0+B4*RPINT + B5*RPIFDIV + B6*RPVOL + B8*RPSACB1 + B9*RPCPI2
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EPFINIIND = B0+B4*RPINT + B6*RPVOL + B7*RPCRUDE + B8*RPSACB1 + B9*RPCPI2
EPFINIIND = B0+B5*RPIFDIV + B6*RPVOL + B7*RPCRUDE + B8*RPSACB1 +B9*RPCPI2

EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B7*RPCRUDE
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B8*RPSACB1
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B9*RPCPI2
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B6*RPVOL+B7*RPCRUDE
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B6*RPVOL+B8*RPSACB1
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B6*RPVOL+B9*RPCPI2
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B7*RPCRUDE+B9*RPCPI2
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+B8*RPSACB1
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+B9*RPCPI2
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B7*RPCRUDE+B8*RPSACB1
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EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B8*RPSACB1+B9*RPCPI2
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EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B6*RPVOL+B7*RPCRUDE+B9*RPCPI2
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EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B3*RTSD+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE
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EPFINIIND = B0+BI*RPDJ+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B8*RPSACB1+B9*RPCPI2
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EPFINIIND = B0+BI*RPDJ+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
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EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B4*RPINT+B6*RPVOL+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B4*RPINT+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1
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EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B9*RPCPI2

EPFINIIND = B0+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0 +B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B2*RPDGOLD+B4*RPINT+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0 +B2*RPDGOLD+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B9*RPCPI2
EPFINIIND = B0+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B3*RTSD+B4*RPINT+B5*RPIFDIV+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B3*RTSD+B4*RPINT+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B3*RTSD+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+
B6*RPVOL+B7*RPCRUDE
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+
B6*RPVOL+B8*RPSACB1
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+
B6*RPVOL+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+
B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+
B7*RPCRUDE+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B6*RPVOL+
B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B6*RPVOL+
B7*RPCRUDE+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B6*RPVOL+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B4*RPINT+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B8*RPSACB1
EPFINIIND = B0+B1*RPDJ+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B9*RPCPI2
EPFINIIND = B0+B1*RPDJ+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+

B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B3*RTSD+B4*RPINT+B5*RPIFDIV+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B3*RTSD+B4*RPINT+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B3*RTSD+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B8*RPSACB1

EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B9*RPCPI2

EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B4*RPINT+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B8*RPSACB1

EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+B7*RPCRUDE+
B8*RPSACB1+B9*RPCPI2

EPFINIIND = B0+B1*RPDJ+B2*RPDGOLD+B3*RTSD+B4*RPINT+B5*RPIFDIV+B6*RPVOL+
B7*RPCRUDE+ B8*RPSACB1+B9*RPCPI2

APPENDIX 4

Risk factors included in the LFM chosen for meeting the highest Adjusted R^2 criterion over the 120 month period 1 April 1988 to 31 March 1998

Period	DJ	GOLD	TSD	INT	IFDIVD	VOL	CRUDE	SACOB1	CPI2	$ADJR^2$
1	✓	✓			✓	✓				.47
2	✓	✓			✓	✓				.51
3	✓	✓			✓	✓				.55
4	✓	✓	✓	✓	✓	✓				.57
5	✓	✓	✓	✓	✓	✓				.55
6	✓	✓		✓	✓	✓				.55
7	✓			✓	✓	✓				.55
8	✓			✓	✓	✓				.54
9	✓			✓	✓	✓				.52
10	✓				✓	✓		✓		.49
11	✓	✓			✓	✓				.52
12	✓			✓		✓			✓	.50
13	✓			✓		✓			✓	.56
14	✓			✓		✓			✓	.55
15	✓	✓				✓				.45
16	✓					✓			✓	.41
17	✓					✓				.42
18.	✓	✓				✓	✓			.44
19	✓		✓			✓	✓			.50
20	✓		✓			✓	✓			.46
21	✓						✓			.46
22	✓		✓				✓			.48
23	✓					✓	✓			.42
24.	✓					✓	✓			.42
25	✓						✓			.40
26	✓		✓	✓		✓	✓			.44
27	✓		✓	✓		✓	✓			.45
28	✓		✓	✓		✓	✓			.46
29.	✓					✓	✓			.41
30	✓						✓			.42
31	✓		✓	✓		✓				.43
32	✓		✓			✓				.22
33	✓			✓						.14

Period	DJ	GOLD	TSD	INT	IFDIVD	VOL	CRUDE	SACOB1	CPI2	$ADJR^2$
34	✓			✓						.13
35	✓			✓						.10
36	✓			✓						.11
37	✓			✓						.15
38	✓						✓			.16
39	✓	✓					✓	✓		.16
40	✓			✓						.15
41	✓			✓						.17
42	✓			✓						.14
43	✓			✓		✓				.14
44	✓			✓						.15
45.	✓			✓		✓				.16
46	✓			✓		✓				.13
47	✓			✓		✓				.08
48	✓			✓		✓				.13
49	✓			✓		✓				.19
50	✓			✓		✓				.18
51	✓			✓		✓				.21
52	✓			✓		✓				.18
53	✓			✓		✓				.17
54	✓			✓		✓				.14
55	✓			✓		✓				.12
56	✓					✓				.15
57	✓					✓				.18
58	✓					✓				.18
59	✓		✓			✓				.22
60	✓					✓				.22
61	✓	✓				✓				.20
62	✓	✓				✓			✓	.18
63	✓	✓				✓			✓	.15
64	✓	✓				✓			✓	.16
65	✓	✓				✓			✓	.17
66	✓	✓				✓		✓		.10
67	✓	✓				✓		✓		.08
68	✓	✓				✓		✓		.07
69		✓				✓				.09
70	✓					✓	✓		✓	.27
71	✓					✓		✓	✓	.37
72	✓					✓		✓	✓	.31
73	✓					✓			✓	.31

Period	DJ	GOLD	TSD	INT	IFDIVD	VOL	CRUDE	SACOB1	CPI2	ADJR^2
74	✓					✓	✓		✓	.25
75	✓					✓	✓		✓	.25
76	✓					✓	✓		✓	.28
77	✓					✓	✓		✓	.25
78	✓				✓	✓	✓		✓	.25
79	✓					✓			✓	.20
80	✓	✓				✓	✓	✓	✓	.35
81	✓	✓				✓	✓	✓	✓	.29
82	✓				✓	✓			✓	.27
83	✓					✓			✓	.23
84	✓					✓			✓	.23
85	✓					✓			✓	.23
86	✓					✓			✓	.23
87	✓					✓			✓	.19
88	✓					✓	✓		✓	.16
89	✓					✓			✓	.15
90	✓					✓			✓	.13
91	✓					✓			✓	.11
92	✓					✓			✓	.10
93	✓					✓			✓	.08
94	✓					✓			✓	.03
95	✓					✓			✓	.07
96	✓		✓			✓			✓	.08
97	✓		✓			✓				.09
98	✓		✓			✓				.09
99	✓		✓	✓		✓	✓			.08
100	✓		✓	✓		✓	✓			.10
101	✓		✓	✓		✓	✓			.15
102	✓		✓	✓		✓				.09
103	✓		✓	✓		✓				.08
104	✓		✓	✓		✓				.09
105	✓		✓	✓		✓	✓			.08
106	✓			✓			✓			.04
107.	✓			✓			✓			.04
108	✓		✓	✓						.02
109	✓			✓			✓			.03
110	✓			✓						.08
111	✓			✓						.08
112	✓			✓	✓			✓		.13
113				✓	✓		✓	✓		.15

Period	DJ	GOLD	TSD	INT	IFDIVD	VOL	CRUDE	SACOB1	CPI2	$ADJR^2$
114.	✓			✓	✓			✓		.16
115	✓		✓	✓	✓	✓		✓		.13
116	✓			✓		✓		✓	✓	.20
117	✓			✓	✓	✓		✓	✓	.41
118	✓			✓	✓	✓		✓	✓	.44
119	✓			✓		✓		✓	✓	.42
120	✓	✓		✓	✓	✓		✓	✓	.52

The regressors are unexpected changes in the rate of change of: DJ = Dow-Jones index, GOLD = Dollar gold price, TSD = Term structure of interest rates, INT = Three-month bankers' acceptance rate, IFDIV = Dividends, VOL = Volume of shares traded, CRUDE = Dollar Dubai crude oil spot price, SACOBI = SACOB Business confidence index lagged one month and CPI2 = Consumer price index lagged two months

APPENDIX 5

The p-value of the risk factor co-efficients, in the best subset LFM for the 87 four-week periods from 20 October 1991 to 21 June 1998

Period	DJ	GOLD	TSD	INT	IFDIVD	VOL	CRUDE	SACOB4	CPI8	$ADJR^2$
1	.00	.01			.05		.00	.08		.15
2	.00	.01			.07		.00	.06		.15
3	.00	.03			.06		.00	.07		.14
4	.00	.02			.04		.00	.04		.14
5	.00	.02			.04	.09	.00	.04		.15
6	.00	.05			.06	.10	.01	.08		.14
7	.00	.09	.26		.15	.07	.01	.12		.13
8	.00	.05			.07	.09	.00	.09		.13
9	.00	.13			.06	.04	.02	.11		.15
10	.00	.16			.12	.05	.04	.13		.15
11	.00	.26			.08	.06	.07	.15		.15
12	.00	.27			.06	.06	.07	.12		.17
13	.00	.20			.03	.08	.08	.12		.17
14	.00	.17			.02	.16	.08	.07		.18
15	.00	.19		.22	.00	.09	.09			.19
16	.00	.07		.24	.00	.07	.05	.30		.20
17	.00	.04			.00	.04	.02	.31		.20
18	.00	.11			.00	.02	.05	.33		.19
19	.00	.24		.27	.00	.01	.08			.19
20	.00			.29	.00	.01	.13			.19
21	.00	.28		.35	.00	.02	.05			.19
22	.00			.23	.00	.02	.08			.18
23	.00			.23	.00	.03	.07			.18
24	.00			.23	.00	.03	.09			.18
25	.00			.26	.00	.02	.03			.20
26	.00			.22	.00	.03		.25		.13
27	.00			.13	.00	.02				.13
28	.00		.13		.00	.03				.14
29	.00			.15	.00	.01				.15
30	.00			.13	.00	.01				.13
31	.00			.14	.00	.01				.16

Period	DJ	GOLD	TSD	INT	IFDIVD	VOL	CRUDE	SACOB4	CPI8	ADJR^2
32	.01			.16	.00	.01	.23			.14
33	.01			.23	.00	.01	.20			.14
34	.00			.18	.00	.00	.25			.17
35	.00	.17			.00	.01	.13			.15
36	.00	.20			.01	.02	.14			.13
37	.00	.12		.21	.00	.01	.16			.16
38	.00	.14	.31	.12	.00	.01	.19			.15
39	.00	.15	.19	.10	.00	.01	.25			.16
40	.00	.12	.09	.01	.02	.00	.19			.19
41	.00	.09	.07	.01	.01	.00	.08			.21
42	.00	.10	.09	.02	.00	.00	.05		.31	.20
43	.00	.15	.09	.03	.00	.00	.05		.17	.21
44	.00	.21	.14	.05	.00	.04	.05		.17	.16
45	.00	.25	.20	.04	.00	.05	.09		.22	.15
46	.00	.28	.18	.02	.00	.04	.11		.20	.15
47	.00		.08	.02	.01	.03	.13		.18	.16
48	.00		.09	.05	.02	.07	.17		.18	.15
49	.00		.10	.04	.03	.07	.20		.18	.14
50	.00	.26	.10	.11	.07	.08	.28		.18	.12
51	.00	.16	.03	.04	.08	.06	.26		.28	.12
52	.00	.27	.01	.03	.19	.05	.31			.11
53	.00		.00	.02	.21	.02	.27			.13
54	.00		.00	.02	.29	.02	.19			.13
55	.00		.00	.03	.31	.02	.19			.13
56	.00		.00	.02	.24	.04	.13			.13
57	.00		.00	.02	.27	.02	.12			.14
58	.00		.00	.01		.01	.08			.13
59	.00		.00	.01		.01	.04			.16
60	.00	.28	.00	.01		.02	.04			.16
61	.00		.00	.00		.01	.19			.17
62	.00	.29	.00	.00		.02	.21		.24	.16
63	.00	.17	.00	.00		.01	.24		.20	.17
64	.00	.24	.00	.00		.03	.23		.20	.17
65	.00		.00	.00		.02	.22		.20	.17
66	.00		.00	.00		.04	.26	.22	.28	.17
67	.00		.00	.00		.04	.28	.20	.28	.17
68	.03	.17	.00	.00		.08	.21	.24		.14
69	.01	.19	.00	.00		.12	.25	.28		.15
70	.01	.27	.01	.00		.10		.27		.14
71	.00		.00	.00		.07		.23		.17

Period	DJ	GOLD	TSD	INT	IFDIVD	VOL	CRUDE	SACOB4	CPI8	$ADJR^2$
72	.00		.00	.00		.06		.24	.26	.18
73	.02		.00	.00		.08		.25	.26	.15
74	.00		.01	.00		.03				.19
75	.00		.02	.00		.02				.21
76	.01		.03	.00		.03				.16
77	.00		.03	.00		.04				.16
78	.00		.05	.00		.03				.17
79	.00		.08	.00		.02				.16
80	.00		.13	.00		.05				.15
81	.00		.14	.00		.02		.30		.27
82	.00	.24	.24	.00		.01				.27
83	.00	.14	.17	.00		.04		.28		.29
84	.00	.00		.00		.01			.15	.32
85	.00	.02		.00		.02		.29	.05	.30
86	.00	.00		.00		.04		.27	.05	.30
87	.00	.00		.00.		.07		.27	.03	.33

The regressors are unexpected changes in the rate of change of: DJ = Dow-Jones index, GOLD = Dollar gold price, TSD = Term structure of interest rates, INT = Three-month bankers' acceptance rate, IFDIV = Dividends, VOL = Volume of shares traded, CRUDE = Dollar Dubai crude oil spot price, SACOB4 = SACOB Business confidence index lagged four weeks and CPI8 = Consumer price index lagged eight weeks

p-value is the probability that the risk factor is not priced. We regard a risk factor to be priced if $p<.05$

APPENDIX 6

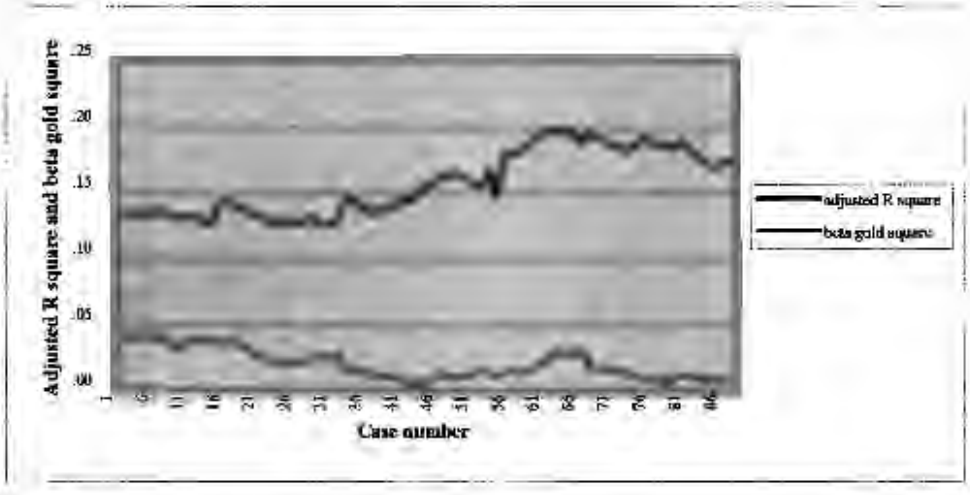
Percentage of time a risk factor appears in the LFM during the three subperiods

	DJ	GOLD	TSD	INT	IFDIV
PERIOD 1	100%	69%	7%	41%	100%
PERIOD 2	100%	51%	72%	93%	97%
PERIOD 3	100%	45%	86%	100%	0%
AVERAGE	100%	55%	55%	78%	66%
	VOL	**CRUDE**	**SACOB4**	**CPI8**	
PERIOD 1	86%	86%	62%	0%	
PERIOD 2	100%	93%	0%	34%	
PERIOD 3	100%	38%	45%	41%	
AVERAGE	95%	72%	36%	25%	

The regressors are the unexpected rate of change of: DJ = Dow-Jones index, GOLD = Dollar gold price, TSD = Term structure of interest rates, INT = Three-month bankers' acceptance rate, IFDIV = Dividends, VOL = Volume of shares traded, CRUDE = Dollar Dubai crude oil spot price, SACOB4 = SACOB Business confidence index lagged four weeks, CPI8 = Consumer price index lagged eight weeks
Period 1: 20 October 1991 to 9 January 1993
Period 2: 10 January 1994 to 31 March 1996
Period 3: 1 April 1996 to 21 June 1998

APPENDIX 7

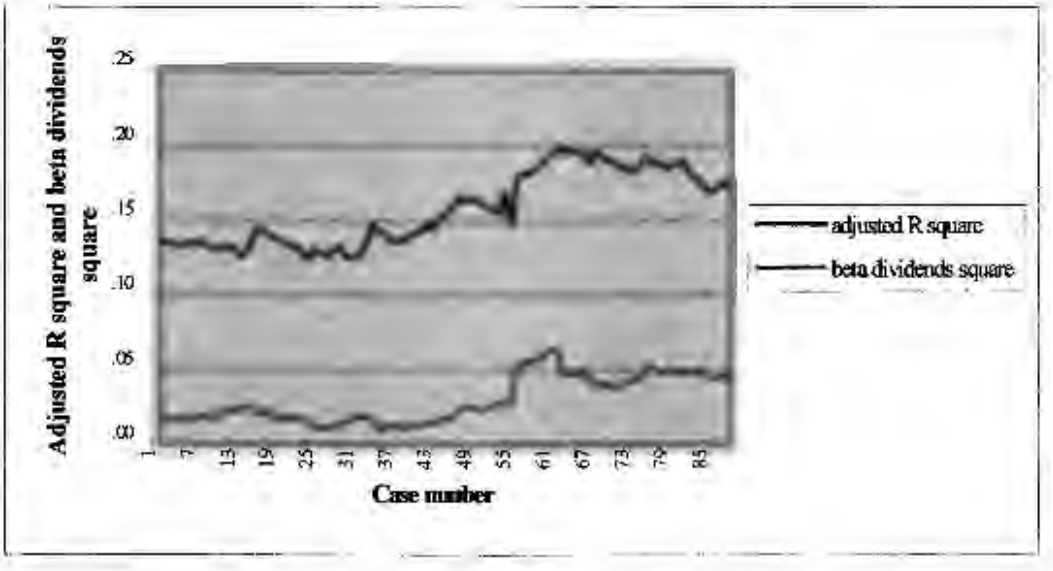
Graphs showing the unique contribution of various risk factors to the overall explanatory power of the LFM, with nine risk factors, from 20 October 1991 to 21 June 1998



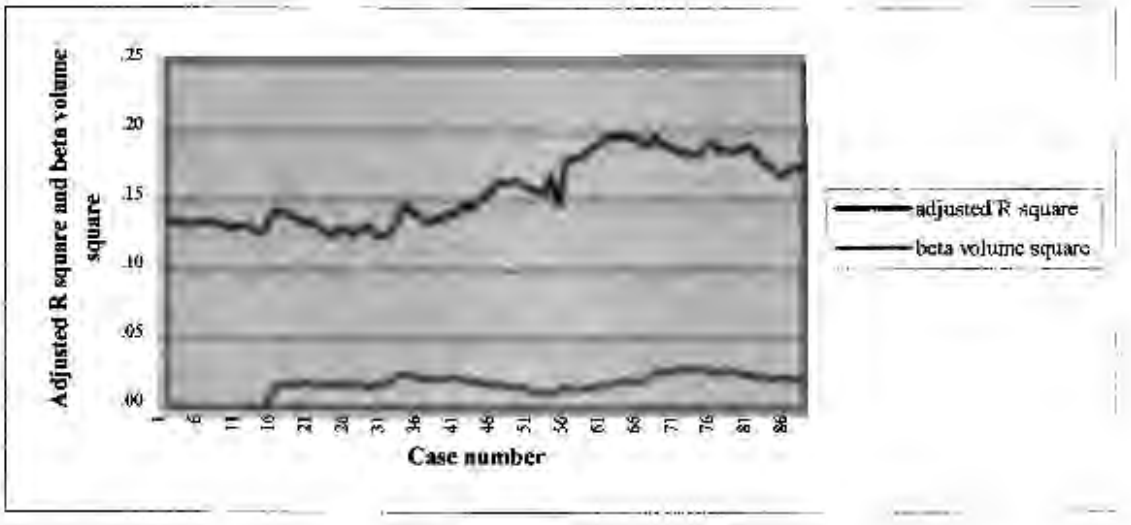
Graph showing the unique contribution of the gold price risk factor to the overall explanatory power of the LFM vs time

Graph showing the unique contribution of the term structure of interest rates risk factor to the overall explanatory power of the LFM vs time

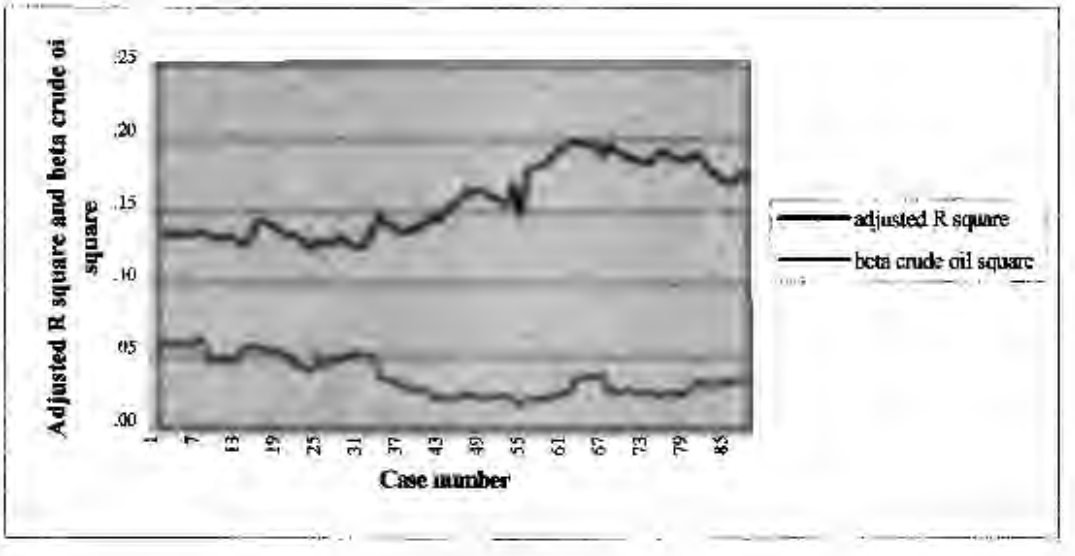
Graph showing the unique contribution of the BA rate risk factor to the overall explanatory power of the LFM vs time



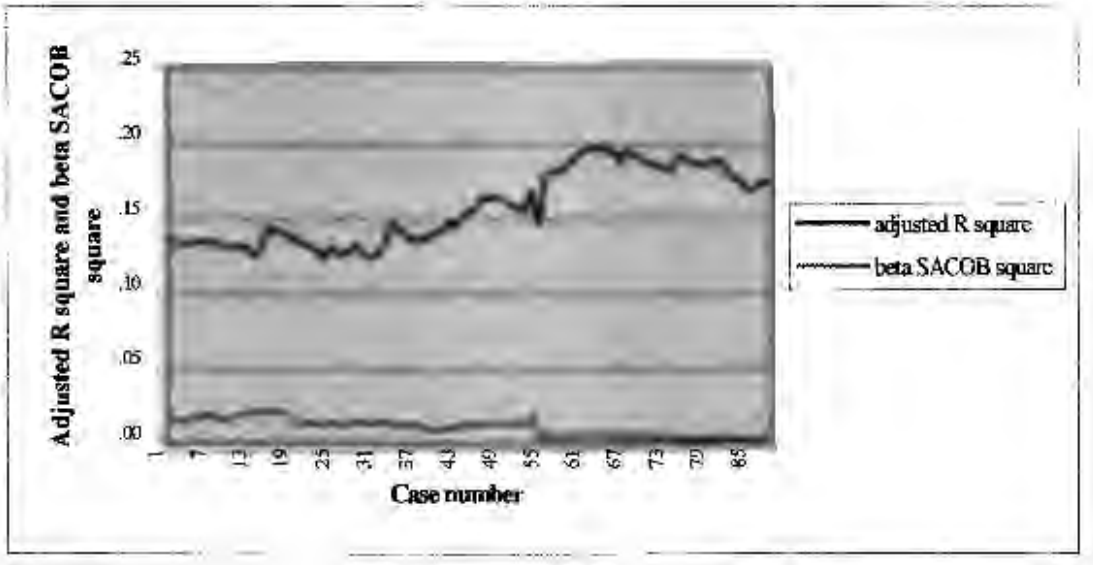
Graph showing the unique contribution of the dividend risk factor to the overall explanatory power of the LFM vs time



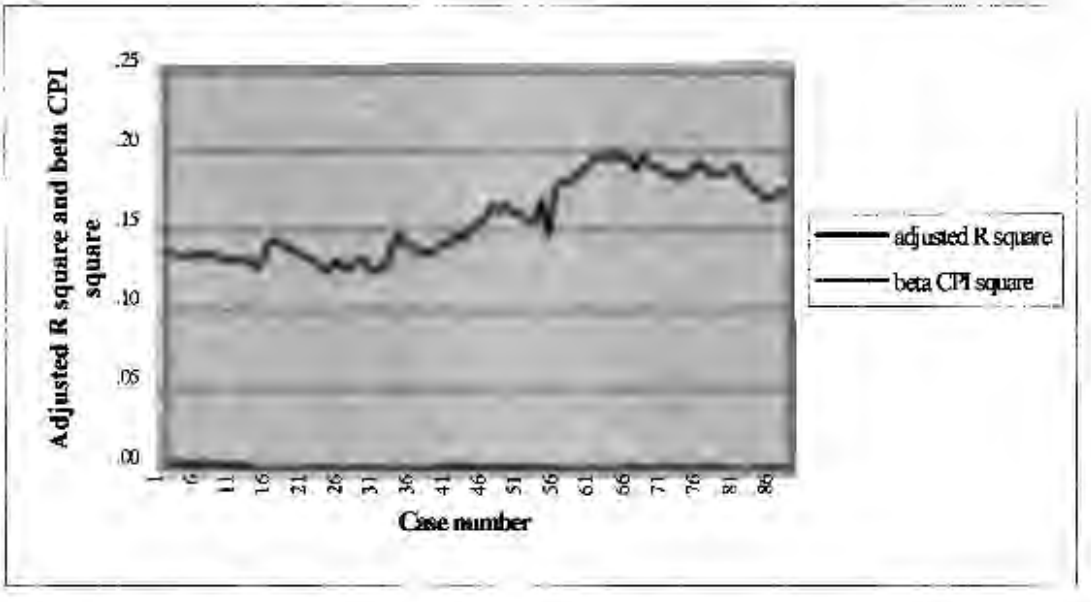
Graph showing the unique contribution of the volume of shares traded on the JSE risk factor to the overall explanatory power of the LFM vs time



Graph showing the unique contribution of the crude oil price risk factor to the overall explanatory power of the LFM vs time



Graph showing the unique contribution of the SACOB BCI risk factor to the overall explanatory power of the LFM vs time



Graph showing the unique contribution of the CPI risk factor to the overall explanatory power of the LFM vs time

APPENDIX 8

Risk premia (λ) priced over each period from 20 October 1991 to 21 June 1998 in the APTM when the ITNLSUR and N3SLS approaches were used with both the Gauss and Marquardt minimisation techniques

	DOW-JONES				GOLD				DIVIDENDS			
OBS	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
1	0.000	0.001	0.038	0.059	0.700	0.893	0.478	0.858	0.010	0.005	0.042	0.074
2	0.000	0.001	0.007	0.013	0.108	0.156	0.957	0.660	0.016	0.003	0.012	0.028
3	0.000	0.000	0.030	0.861	0.060	0.129	0.127	0.861	0.039	0.006	0.013	0.862
4	0.000	0.000	0.002	0.001	0.063	0.153	0.768	0.706	0.197	0.148	0.259	0.778
5	0.006	0.001	0.060	0.024	0.046	0.116	0.987	0.549	0.487	0.218	0.375	0.911
6	0.000	0.005	0.093	0.059	0.166	0.508	0.512	0.815	0.891	0.630	0.877	0.488
7	0.000	0.013	0.049	0.049	0.026	0.038	0.739	0.546	0.308	0.447	0.298	0.098
8	0.000	0.004	0.023	0.020	0.185	0.363	0.972	0.706	0.905	0.681	0.853	0.632
9	0.000	0.003	0.053	0.089	0.188	0.539	0.660	0.659	0.699	0.871	0.950	0.285
10	0.008	0.385	0.167	0.273	0.062	0.288	0.867	0.347	0.689	0.636	0.894	0.310
11	0.009	0.224	0.103	0.095	0.016	0.061	0.450	0.136	0.577	0.766	0.511	0.244
12	0.007	0.040	0.060	0.041	0.012	0.049	0.300	0.124	0.586	0.909	0.423	0.270
13	0.008	0.234	0.025	0.012	0.011	0.039	0.104	0.051	0.299	0.324	0.253	0.155
14	0.000	0.001	0.006	0.005	0.003	0.008	0.038	0.025	0.263	0.448	0.131	0.089
15	0.000	0.001	0.001	0.601	0.000	0.001	0.010	0.021	0.465	0.990	0.070	0.944
16	0.387	0.969	0.011	0.255	0.013	0.036	0.116	0.019	0.024	0.088	0.051	0.004
17	0.049	0.148	0.008	0.066	0.026	0.037	0.192	0.146	0.008	0.035	0.020	0.001
18	0.001	0.990	0.001	0.000	0.099	0.990	0.153	0.431	0.002	0.990	0.009	0.008
19	0.056	0.105	0.988	0.107	0.009	0.065	0.988	0.101	0.236	0.122	0.988	0.140
20	n/c	0.000	0.993	0.000	n/c	.	.	.	n/c	0.000	0.993	0.000
21	0.269	0.143	0.987	0.115	0.925	0.534	0.987	0.813	0.219	0.052	0.987	0.097
22	0.055	0.234	0.080	0.014		.	.	.	0.003	0.000	0.064	0.010
23	0.019	0.051	0.065	0.008		.	.	.	0.335	0.050	0.116	0.063

	DOW-JONES				GOLD				DIVIDENDS			
OBS	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
24	0.018	0.910	0.003	0.003		.	.	.	0.010	0.000	0.012	0.105
25	0.037	0.500	0.006	0.003		.	.	.	0.190	0.000	0.871	0.942
26	0.037	0.916	0.305	0.000		.	.	.	0.144	0.000	0.991	0.052
27	0.000	0.003	0.000	0.000		.	.	.	0.012	0.002	0.027	0.019
28	0.160	0.443	0.057	0.028		.	.	.	0.002	0.003	0.065	0.040
29	0.000	0.017	0.005	0.005		.	.	.	0.011	0.000	0.048	0.047
30	0.002	0.006	0.277	0.007		.	.	.	0.003	0.002	0.244	0.020
31	0.000	0.012	0.068	0.010		.	.	.	0.006	0.000	0.137	0.054
32	0.001	0.003	0.978	0.055		.	.	.	0.096	0.011	0.978	0.341
33	n/c	0.004	0.000	0.000	n/c	.	.	.		0.006	0.018	0.036
34	n/c	0.001	0.089	0.840	n/c	.	.	.	n/c	0.300	0.273	0.841
35	0.296	0.000	0.051	0.000	0.418	0.173	0.212	0.042	0.381	0.254	0.308	0.119
36	n/c	0.001	0.147	0.000	n/c	0.116	0.233	0.023	n/c	0.234	0.255	0.116
37	n/c	0.882	0.759	0.491	n/c	0.887	0.763	0.548	n/c	0.881	0.758	0.498
38	0.168	0.224	0.226	0.072	0.764	0.773	0.411	0.461	0.252	0.262	0.258	0.112
39	n/c	0.000	0.019	0.030	n/c	0.622	0.022	0.008	n/c	0.052	0.140	0.339
40	0.001	0.002	0.015	0.135	0.052	0.085	0.039	0.018	0.049	0.122	0.256	0.813
41	n/c	0.000	0.117	0.003	n/c	0.319	0.132	0.082	n/c	0.031	0.138	0.033
42	0.138	0.939	0.178	0.672	0.727	0.967	0.862	0.545	0.526	0.973	0.652	0.496
43	0.279	0.018	0.739	0.750	0.937	0.177	0.749	0.759	0.358	0.222	0.751	0.758
44	n/c	0.018	0.984	0.019	n/c	0.289	0.984	0.148	n/c	0.101	0.984	0.142
45	n/c	0.000	0.651	0.697	n/c	0.894	0.708	0.739	n/c	0.004	0.667	0.706
46	n/c	0.000	0.728	0.728	n/c	0.525	0.741	0.740	n/c	0.019	0.735	0.734
47	0.683	0.069	0.321	0.241		.	.	.	0.457	0.261	0.986	0.513
48	0.018	0.015	0.219	0.101		.	.	.	0.024	0.024	0.919	0.310
49	0.020	0.026	0.426	0.280		.	.	.	0.016	0.023	0.565	0.924
50	0.080	0.104	0.188	0.187	0.126	0.130	0.617	0.270	0.130	0.201	0.570	0.345
51	0.047	0.049	0.693	0.732	0.185	0.183	0.259	0.270	0.067	0.082	0.497	0.507
52	0.188	0.045	0.451	0.385	0.428	0.328	0.067	0.039	0.227	0.113	0.058	0.033
53	0.006	0.003	0.001	0.004		.	.	.		0.036	0.000	0.001
54	0.000	0.000	0.200	0.161		.	.	.	0.480	0.176	0.037	0.440

	DOW-JONES				GOLD				DIVIDENDS			
OBS	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
55	0.002	0.005	0.000	0.006		.	.	.		0.576	0.015	0.077
56	0.001	0.004	0.008	0.022		.	.	.		0.318	0.099	0.089
57	0.043	0.123	0.001	0.771		.	.	.	0.458	0.001	0.008	0.006
58	0.056	0.121	0.047	0.770		.	.	.		.	.	.
59	0.045	0.039	0.033	0.048		.	.	.		.	.	.
60	0.062	0.187	0.747	0.522	0.134	0.775	0.447	0.357		.	.	.
61	0.073	0.419	0.036	0.010		.	.	.		.	.	.
62	0.087	0.111	0.719	0.922	0.243	0.369	0.137	0.091		.	.	.
63	0.065	0.257	0.631	0.784	0.037	0.036	0.018	0.014		.	.	.
64	0.076	0.040	0.267	0.457	0.024	0.059	0.063	0.672		.	.	.
65	0.097	0.262	0.556	0.408		.	.	.		.	.	.
66	0.048	0.102	0.021	0.038		.	.	.		.	.	.
67	0.166	0.122	0.019	0.027		.	.	.		.	.	.
68	0.283	0.005	0.142	0.000	0.266	0.018	0.153	0.015		.	.	.
69	n/c	0.011	0.987	0.591	n/c	0.005	0.987	0.588	n/c	.	.	.
70	n/c	0.009	0.995	0.680	n/c	0.045	0.995	0.686	n/c	.	.	.
71	n/c	0.004	0.993	0.654	n/c	.	.	.	n/c	.	.	.
72	0.519	0.636	0.061	0.029		.	.	.		.	.	.
73	0.593	0.429	0.104	0.137		.	.	.		.	.	.
74	0.155	0.003	0.005	0.059		.	.	.		.	.	.
75	0.291	0.003	0.033	0.033		0.000	.	.		.	.	.
76	0.183	0.005	0.060	0.059		0.000	.	.		.	.	.
77	0.253	0.002	0.972	0.189		0.000	.	.		.	.	.
78	0.110	0.991	0.033	0.030		0.991	.	.		.	.	.
79	0.106	0.000	0.035	0.034		0.023	.	.		.	.	.
80	0.022	0.311	0.007	0.007		0.784	.	.		.	.	.
81	0.007	0.003	0.002	0.000		.	.	.		.	.	.
82	0.190	0.003	0.016	0.001	0.254	0.000	0.097	0.000		.	.	.
83	0.089	0.005	0.004	0.004	0.175	0.000	0.127	0.127		.	.	.
84	n/c	0.002	0.991	0.001	n/c	0.000	0.991	0.000	n/c	.	.	.
85	n/c	0.991	0.992	0.053	n/c	0.991	0.992	0.000	n/c	.	.	.

	DOW-JONES				GOLD				DIVIDENDS			
OBS	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
86	0.048	0.000	0.749	0.052	0.015	0.023	0.798	0.153		.	.	.
87	0.251	0.311	0.084	0.081	0.934	0.784	0.961	0.948		.	.	.

	CRUDE OIL				SACOB				VOLUME			
	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
OBS	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
1	0.001	0.004	0.022	0.037	0.416	0.350	0.294	0.239		.	.	.
2	0.001	0.005	0.003	0.006	0.063	0.033	0.028	0.017		.	.	.
3	0.056	0.719	0.138	0.862	0.244	0.001	0.000	0.863		.	.	.
4	0.172	0.922	0.445	0.323	0.006	0.000	0.000	0.000		.	.	.
5	0.293	0.688	0.933	0.897	0.000	0.000	0.000	0.000	0.129	0.189	0.058	0.079
6	0.472	0.348	0.382	0.336	0.000	0.000	0.000	0.000	0.174	0.295	0.148	0.093
7	0.549	0.127	0.157	0.151	0.001	0.014	0.000	0.000	0.180	0.810	0.060	0.058
8	0.309	0.520	0.379	0.238	0.000	0.000	0.000	0.000	0.286	0.233	0.108	0.073
9	0.564	0.142	0.253	0.128	0.000	0.000	0.000	0.000	0.040	0.143	0.046	0.047
10		0.126	0.200	0.106	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.006
11	0.624	0.335	0.250	0.132	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.005
12	0.718	0.409	0.253	0.184	0.005	0.002	0.000	0.000	0.000	0.000	0.002	0.002
13	0.258	0.131	0.196	0.147	0.003	0.007	0.000	0.001	0.001	0.006	0.005	0.006
14	0.684	0.405	0.334	0.296	0.001	0.001	0.000	0.000	0.002	0.003	0.005	0.005
15	0.953	0.602	0.524	0.677		.	.	.	0.001	0.002	0.052	0.010
16		0.250	0.241	0.074	0.001	0.008	0.000	0.000	0.002	0.012	0.003	0.000
17	0.335	0.155	0.151	0.027	0.001	0.003	0.000	0.000	0.010	0.013	0.019	0.001
18	0.642	0.990	0.414	0.541	0.001	0.990	0.000	0.000	0.940	0.990	0.136	0.412
19	0.160	0.212	0.988	0.807		.	.	.	0.007	0.057	0.988	0.086
20	n/c	0.881	0.993	0.535	n/c	.	.	.	n/c	0.000	0.993	0.001
21	0.742	0.819	0.987	0.511		.	.	.	0.226	0.084	0.987	0.113
22	0.197	0.130	0.954	0.266		.	.	.	0.001	0.004	0.066	0.007
23	0.148	0.186	0.538	0.120		.	.	.	0.002	0.021	0.054	0.004
24	0.295	0.997	0.448	0.072		.	.	.	0.001	0.047	0.002	0.001
25	0.031	0.577	0.013	0.009		.	.	.	0.000	0.007	0.001	0.001
26		.	.	.	0.001	0.033	0.001	0.000	0.268	0.227	0.982	0.092
27		.	.	.		.	.	.	0.005	0.025	0.004	0.006
28		.	.	.		.	.	.	0.662	0.381	0.097	0.071
29		.	.	.		.	.	.	0.050	0.020	0.018	0.024
30		.	.	.		.	.	.	0.663	0.213	0.017	0.227
31		.	.	.		.	.	.	0.886	0.006	0.132	0.074

	CRUDE OIL				SACOB				VOLUME			
	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
OBS	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
32	0.000	0.000	0.979	0.051		.	.	.	0.518	0.316	0.978	0.110
33	n/c	0.002	0.006	0.019		.	.	.	n/c	0.112	0.661	0.236
34	n/c	0.929	0.143	0.854		.	.	.	n/c	0.100	0.066	0.842
35	0.605	0.721	0.101	0.330		.	.	.	0.342	0.077	0.038	0.000
36	n/c	0.866	0.404	0.989		.	.	.	n/c	0.092	0.136	0.000
37	n/c	0.876	0.906	0.889		.	.	.	n/c	0.917	0.763	0.517
38	0.338	0.344	0.561	0.280		.	.	.	0.968	0.847	0.288	0.161
39	n/c	0.740	0.033	0.008		.	.	.	n/c	0.692	0.022	0.013
40	0.019	0.014	0.013	0.002		.	.	.	0.890	0.377	0.018	0.073
41	n/c	0.493	0.126	0.505		.	.	.	n/c	0.335	0.113	0.000
42	0.668	0.976	0.894	0.550		.	.	.	0.964	0.973	0.135	0.398
43	0.716	0.074	0.762	0.772		.	.	.	0.872	0.568	0.786	0.782
44	n/c	0.157	0.984	0.237	n/c	.	.	.	n/c	0.639	0.986	0.894
45	n/c	0.149	0.720	0.749	n/c	.	.	.	n/c	0.818	0.866	0.974
46	n/c	0.098	0.771	0.771	n/c	.	.	.	n/c	0.466	0.902	0.902
47	0.835	0.605	0.725	0.773		.	.	.	0.701	0.638	0.468	0.477
48	0.072	0.047	0.815	0.794		.	.	.	0.704	0.447	0.532	0.640
49	0.239	0.240	0.960	0.991		.	.	.	0.481	0.754	0.346	0.433
50	0.137	0.134	0.791	0.566		.	.	.	0.245	0.399	0.297	0.283
51	0.077	0.078	0.317	0.335		.	.	.	0.287	0.467	0.712	0.725
52	0.186	0.057	0.079	0.048		.	.	.	0.768	0.928	0.757	0.934
53	0.015	0.010	0.071	0.039		.	.	.	0.678	0.928	0.012	0.015
54	0.001	0.002	0.063	0.014		.	.	.	0.258	0.888	0.778	0.166
55	0.000	0.000	0.315	0.091		.	.	.	0.061	0.119	0.729	0.335
56	0.000	0.000	0.097	0.298		.	.	.	0.929	0.481	0.019	0.022
57	0.004	0.000	0.030	0.003		.	.	.	0.072	0.015	0.022	0.019
58	0.025	0.000	0.202	0.782		.	.	.	0.068	0.274	0.057	0.770
59	0.016	0.000	0.001	0.001		.	.	.	0.054	0.040	0.006	0.028
60	0.027	0.001	0.067	0.042		.	.	.	0.042	0.105	0.074	0.060
61	0.058	0.053	0.089	0.478		.	.	.	0.074	0.175	0.141	0.001
62	0.048	0.021	0.028	0.015		.	.	.	0.024	0.017	0.038	0.022

	CRUDE OIL				SACOB				VOLUME			
	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
OBS	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
63	0.039	0.003	0.007	0.004		.	.	.	0.090	0.798	0.536	0.692
64	0.041	0.001	0.002	0.015		.	.	.	0.127	0.852	0.236	0.005
65	0.036	0.001	0.001	0.001		.	.	.	0.148	0.796	0.257	0.170
66	0.042	0.125	0.097	0.114	0.092	0.078	0.001	0.001	0.217	0.383	0.182	0.209
67	0.181	0.151	0.067	0.111	0.154	0.099	0.002	0.002	0.326	0.348	0.210	0.286
68	0.264	0.063	0.164	0.045	0.247	0.008	0.105	0.042	0.244	0.059	0.119	0.012
69	n/c	0.013	0.987	0.601	n/c	0.004	0.987	0.606	n/c	0.013	0.987	0.597
70	n/c	.	.	.	n/c	0.001	0.995	0.690	n/c	0.006	0.995	0.680
71	n/c	.	.	.	n/c	0.011	0.993	0.667	n/c	0.003	0.993	0.655
72	0.052	.	.	.	0.052	0.062	0.045	0.131	0.395	0.444	0.030	0.019
73	0.035	.	.	.	0.035	0.061	0.013	0.008	0.169	0.183	0.040	0.162
74		.	.	.		0.295	.	.	0.121	0.103	0.011	0.169
75		.	.	.		.	.	.	0.425	0.888	0.391	0.390
76		.	.	.		0.688	.	.	0.687	0.905	0.175	0.169
77		.	.	.		.	.	.	0.899	0.093	0.972	0.285
78		.	.	.		0.991	.	.	0.385	0.991	0.024	0.023
79		.	.	.		0.100	.	.	0.283	0.650	0.029	0.032
80		.	.	.		0.116	.	.	0.104	0.020	0.006	0.006
81	0.126	.	.	.	0.223	0.295	0.243	0.065	0.126	0.103	0.052	0.143
82		.	.	.		.	.	.	0.603	0.888	0.298	0.450
83	0.611	.	.	.	0.611	0.688	0.408	0.407	0.937	0.905	0.652	0.652
84	n/c	.	.	.	n/c	.	.	.	n/c	0.093	0.991	0.271
85	n/c	.	.	.	n/c	0.991	0.992	0.000	n/c	0.991	0.992	0.745
86	0.047	.	.	.	0.047	0.100	0.767	0.645	0.238	0.650	0.753	0.103
87	0.241	.	.	.	0.241	0.116	0.254	0.259	0.025	0.020	0.028	0.029

	RMF/EMP				INTEREST				TERM. STRUCT. INTEREST			
	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
OBS	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
1	0.017	0.001	0.028	0.056		.	.	.		.	.	.
2	0.044	0.001	0.033	0.028		.	.	.		.	.	.
3	0.006	0.000	0.000	0.902		.	.	.		.	.	.
4	0.044	0.000	0.000	0.000		.	.	.		.	.	.
5	0.126	0.001	0.001	0.000		.	.	.		.	.	.
6	0.407	0.004	0.000	0.000		.	.	.		.	.	.
7	0.067	0.009	0.007	0.005		.	.	.	0.061	0.026	0.447	0.395
8	0.989	0.060	0.058	0.029		.	.	.		.	.	.
9	0.115	0.001	0.000	0.000		.	.	.		.	.	.
10	0.066	0.048	0.004	0.003		.	.	.		.	.	.
11	0.116	0.036	0.044	0.030		.	.	.		.	.	.
12	0.055	0.007	0.449	0.352		.	.	.		.	.	.
13	0.118	0.126	0.826	0.901		.	.	.		.	.	.
14	0.077	0.004	0.794	0.598		.	.	.		.	.	.
15	0.001	0.000	0.778	0.723	0.904	0.391	0.532	0.740		.	.	.
16	0.921	0.504	0.289	0.866	0.880	0.437	0.869	0.046		.	.	.
17	0.950	0.165	0.267	0.633		.	.	.		.	.	.
18	0.779	0.990	0.181	0.110		.	.	.		.	.	.
19	0.099	0.069	0.988	0.435	0.244	0.379	0.988	0.257		.	.	.
20	n/c	0.411	0.993	0.023	n/c	.	.	.	n/c	.	.	.
21	0.267	0.042	0.987	0.273	0.236	0.121	0.987	0.157		.	.	.
22	0.018	0.000	0.240	0.633	0.001	0.003	0.078	0.016		.	.	.
23	0.353	0.030	0.271	0.702	0.003	0.029	0.062	0.010		.	.	.
24	0.172	0.000	0.753	0.547	0.000	0.022	0.001	0.001		.	.	.
25	0.360	0.001	0.552	0.280	0.000	0.012	0.001	0.001		.	.	.
26	0.073	0.000	0.009	0.012	0.000	0.006	0.643	0.127		.	.	.
27	0.593	0.006	0.374	0.675	0.000	0.005	0.002	0.006		.	.	.
28	0.014	0.003	0.403	0.639		.	.	.	0.002	0.017	0.069	0.041
29	0.430	0.004	0.931	0.770	0.000	0.001	0.005	0.008		.	.	.
30	0.398	0.012	0.000	0.820	0.000	0.002	0.000	0.010		.	.	.
31	0.587	0.003	0.566	0.831	0.000	0.000	0.073	0.018		.	.	.

	RMF/EMP				INTEREST				TERM. STRUCT. INTEREST			
	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
OBS.	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
32	0.668	0.095	0.978	0.596	0.000	0.000	0.978	0.055		.	.	.
33	n/c	0.114	0.003	0.056	n/c	0.000	0.000	0.002	n/c	.	.	.
34	n/c	0.000	0.023	0.856	n/c	0.204	0.617	0.837	n/c	.	.	.
35	0.310	0.000	0.004	0.077		.	.	.		.	.	.
36	n/c	0.000	0.060	0.210	n/c	.	.	.	n/c	.	.	.
37	n/c	0.882	0.822	0.880	n/c	0.881	0.817	0.868	n/c	.	.	.
38	0.170	0.266	0.808	0.625	0.179	0.242	0.753	0.368	0.185	0.246	0.266	0.167
39	n/c	0.000	0.003	0.001	n/c	0.159	0.006	0.001	n/c	0.004	0.174	0.317
40	0.020	0.001	0.002	0.001	0.011	0.083	0.004	0.000	0.752	0.193	0.532	0.839
41	n/c	0.000	0.113	0.645	n/c	0.137	0.342	0.920	n/c	0.011	0.188	0.057
42	0.113	0.000	0.467	0.669	0.112	0.982	0.169	0.295	0.077	0.963	0.144	0.236
43	0.103	0.468	0.826	0.830	0.071	0.183	0.765	0.791	0.045	0.001	0.737	0.748
44	n/c	0.481	0.985	0.910	n/c	0.162	0.984	0.327	n/c	0.001	0.984	0.000
45	n/c	0.043	0.843	0.828	n/c	0.337	0.663	0.712	n/c	0.001	0.648	0.697
46	n/c	0.225	1.000	0.999	n/c	0.227	0.755	0.755	n/c	0.001	0.729	0.729
47	0.406	0.647	0.143	0.217	0.379	0.123	0.262	0.502	0.319	0.000	0.127	0.242
48	0.023	0.005	0.114	0.119	0.548	0.969	0.145	0.310	0.143	0.032	0.074	0.127
49	0.025	0.011	0.455	0.549	0.492	0.788	0.181	0.348	0.757	0.375	0.103	0.199
50	0.066	0.050	0.138	0.157	0.448	0.257	0.294	0.875	0.193	0.307	0.062	0.135
51	0.058	0.031	0.959	0.962	0.104	0.087	0.584	0.623	0.142	0.114	0.086	0.087
52	0.184	0.023	0.030	0.009	0.232	0.076	0.044	0.020	0.201	0.059	0.255	0.293
53	0.005	0.000	0.001	0.001	0.233	0.094	0.003	0.003	0.035	0.017	0.598	0.693
54	0.000	0.000	0.000	0.000	0.024	0.007	0.000	0.000	0.068	0.037	0.000	0.002
55	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.011	0.003	0.000	0.000
56	0.004	0.000	0.001	0.003	0.002	0.000	0.019	0.011	0.001	0.002	0.004	0.012
57	0.037	0.047	0.000	0.001	0.001	0.000	0.000	0.003	0.017	0.161	0.001	0.062
58	0.005	0.000	0.008	0.752	0.002	0.000	0.680	0.782	0.035	0.002	0.040	0.771
59	0.049	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.041	0.008	0.555	0.308
60	0.042	0.001	0.024	0.015	0.021	0.000	0.044	0.026	0.001	0.002	0.292	0.196
61	0.035	0.002	0.000	0.000	0.051	0.007	0.000	0.009	0.003	0.000	0.000	0.000
62	0.143	0.339	0.000	0.000	0.039	0.001	0.000	0.000	0.041	0.037	0.027	0.062

	RMF/EMP				INTEREST				TERM. STRUCT. INTEREST			
	ITNLSUR		N3SLS		ITNLSUR		N3SLS		ITNLSUR		N3SLS	
OBS.	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ	GAUSS	MARQ
63	0.043	0.048	0.000	0.000	0.005	0.000	0.000	0.000	0.031	0.011	0.114	0.256
64	0.031	0.028	0.000	0.000	0.001	0.006	0.001	0.341	0.045	0.164	0.467	0.270
65	0.049	0.139	0.000	0.000	0.032	0.001	0.000	0.000	0.018	0.047	0.896	0.619
66	0.039	0.265	0.000	0.000	0.018	0.155	0.089	0.052	0.057	0.113	0.018	0.010
67	0.196	0.222	0.000	0.001	0.151	0.092	0.014	0.015	0.191	0.151	0.038	0.019
68	0.299	0.003	0.057	0.281	0.232	0.015	0.087	0.046	0.255	0.000	0.129	0.003
69	n/c	0.066	0.987	0.673	n/c	0.024	0.987	0.633	n/c	0.000	0.987	0.588
70	n/c	0.028	0.995	0.717	n/c	0.019	0.995	0.706	n/c	0.000	0.995	0.682
71	n/c	0.010	0.993	0.694	n/c	0.023	0.993	0.694	n/c	0.000	0.993	0.657
72	0.000	0.011	0.066	0.096	0.015	0.003	0.222	0.215	0.024	0.047	0.751	0.533
73	0.002	0.019	0.015	0.004	0.049	0.015	0.300	0.279	0.015	0.034	0.409	0.261
74	0.077	0.687	0.468	0.200	0.021	0.072	0.040	0.191	0.017	0.001	0.002	0.023
75	0.084	0.037	0.351	0.348	0.042	0.000	0.407	0.397	0.017	0.001	0.009	0.009
76	0.087	0.098	0.199	0.200	0.051	0.000	0.208	0.191	0.031	0.002	0.023	0.023
77	0.209	0.052	0.972	0.266	0.183	0.000	0.972	0.326	0.154	.	0.972	0.161
78	0.085	0.991	0.251	0.285	0.056	0.991	0.698	0.568	0.018	.	0.006	0.006
79	0.118	0.984	0.573	0.695	0.061	0.062	0.072	0.064	0.043	.	0.016	0.019
80	0.252	0.179	0.921	0.941	0.022	0.511	0.074	0.076	0.004	.	0.002	0.002
81	0.198	0.687	0.760	0.114	0.080	0.072	0.056	0.001	0.002	0.001	0.001	0.000
82	0.596	0.037	0.491	0.953	0.208	0.000	0.038	0.000	0.170	0.001	0.015	0.001
83	0.806	0.098	0.620	0.619	0.114	0.000	0.024	0.023	0.085	0.002	0.008	0.007
84	n/c	0.052	0.991	0.208	n/c	0.000	0.991	0.000	n/c	.	.	.
85	n/c	0.991	0.992	0.491	n/c	0.991	0.992	0.000	n/c	.	.	.
86	0.224	0.984	0.841	0.462	0.405	0.062	0.754	0.507		.	.	.
87	0.579	0.179	0.694	0.688	0.119	0.511	0.874	0.862		.	.	.

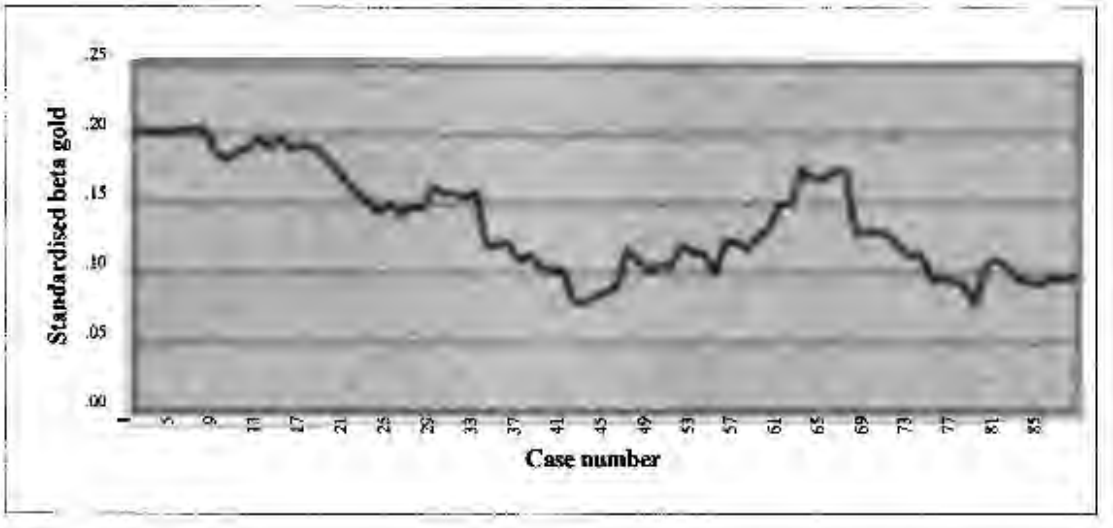
	CPI					CPI			
	ITNLSUR		N3SLS			ITNLSUR		N3SLS	
OBS	GAUSS	MARQ	GAUSS	MARQ	OBS	GAUSS	MARQ	GAUSS	MARQ
1		.	.	.	32		.	.	.
2		.	.	.	33	n/c	.	.	.
3		.	.	.	34	n/c	.	.	.
4		.	.	.	35		.	.	.
5		.	.	.	36	n/c	.	.	.
6		.	.	.	37	n/c	.	.	.
7		.	.	.	38		.	.	.
8		.	.	.	39	n/c	.	.	.
9		.	.	.	40		.	.	.
10		.	.	.	41	n/c	.	.	.
11		.	.	.	42	0.044	0.946	0.095	0.219
12		.	.	.	43	0.021	0.000	0.736	0.748
13		.	.	.	44	n/c	0.000	0.984	0.000
14		.	.	.	45	n/c	0.051	0.644	0.694
15		.	.	.	46	n/c	0.021	0.727	0.727
16		.	.	.	47	0.285	0.000	0.090	0.215
17		.	.	.	48	0.035	0.093	0.041	0.093
18		.	.	.	49	0.013	0.019	0.057	0.154
19		.	.	.	50	0.039	0.070	0.049	0.120
20	n/c	.	.	.	51	0.089	0.127	0.064	0.066
21		.	.	.	52		.	.	.
22		.	.	.	53		.	.	.
23		.	.	.	54		.	.	.
24		.	.	.	55		.	.	.
25		.	.	.	56		.	.	.
26		.	.	.	57		.	.	.
27		.	.	.	58		.	.	.
28		.	.	.	59		.	.	.
29		.	.	.	60		.	.	.
30		.	.	.	61		.	.	.
31		.	.	.	62	0.039	0.001	0.001	0.001

	CPI					CPI			
	ITNLSUR		N3SLS			ITNLSUR		N3SLS	
OBS	GAUSS	MARQ	GAUSS	MARQ	OBS	GAUSS	MARQ	GAUSS	MARQ
63	0.021	0.002	0.006	0.007	76		.	.	.
64	0.034	0.002	0.008	0.000	77		0.535	.	.
65	0.048	0.001	0.002	0.005	78		0.991	.	.
66	0.029	0.104	0.005	0.017	79		0.000	.	.
67	0.215	0.186	0.012	0.028	80		0.000	.	.
68		.	.	.	81		.	.	.
69	n/c	.	.	.	82		.	.	.
70	n/c	.	.	.	83		.	.	.
71	n/c	.	.	.	84	n/c	0.535	0.991	0.031
72	0.000	0.000	0.000	0.000	85	n/c	0.991	0.992	0.000
73	0.000	0.000	0.000	0.000	86	0.000	0.000	0.747	0.002
74		.	.	.	87	0.001	0.000	0.000	0.000
75		.	.	.					

The regressors are unexpected changes in the rate of change of: DOW-JONES=Dow-Jones index, GOLD = Dollar gold price, TERM STRUCT. INTEREST= Term structure of interest rates, INTEREST = Three-month bankers acceptance rate, DIVIDENDS =Dividends paid by companies in the financial and industrial sector of the JSE, VOLUME = Volume of shares traded, CRUDE OIL= Dollar Dubai crude oil spot price, SACOB = SACOB Business Confidence Index lagged four weeks and CPI = Consumer price index lagged eight weeks ,RMF= Residual market factor, EMP= Excess market portfolio.
p-value is the probability that the risk factor is not priced. We regard a risk factor to be priced if $p<.05$
n/c denotes no convergence.

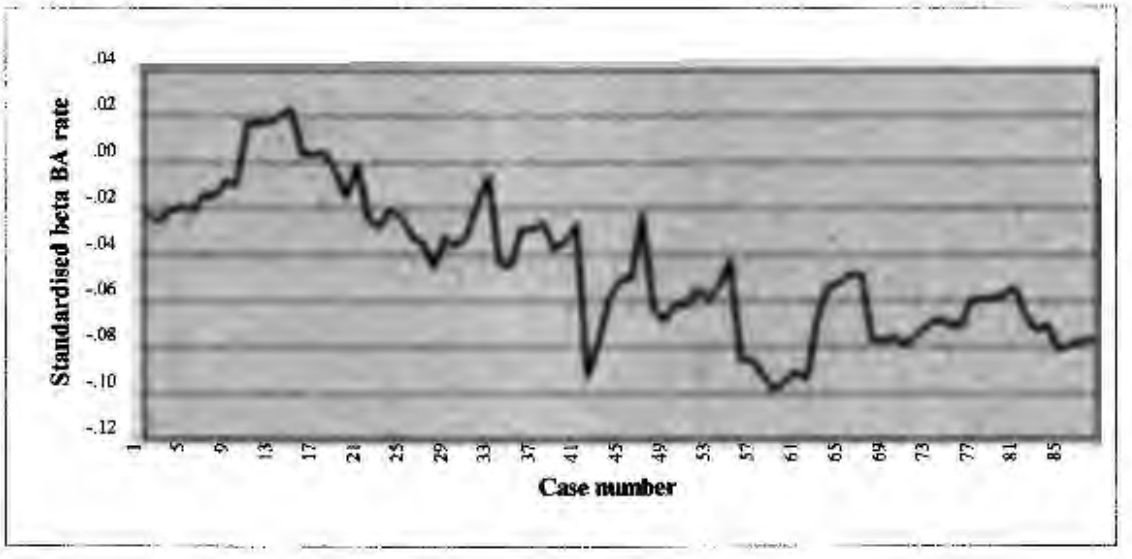
APPENDIX 9

Graphs of the standardised beta of nine risk factors appearing in the same LFM vs time from 20 October 1991 to 21 June 1998 (87 four-week periods)

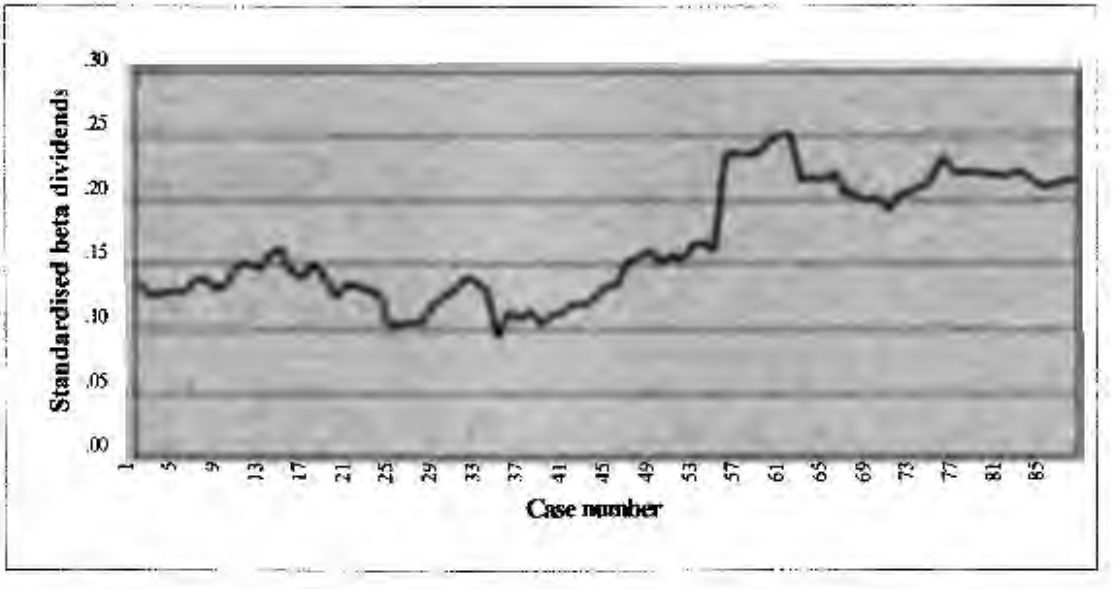


Graph of the standardised beta of the gold price risk factor vs time

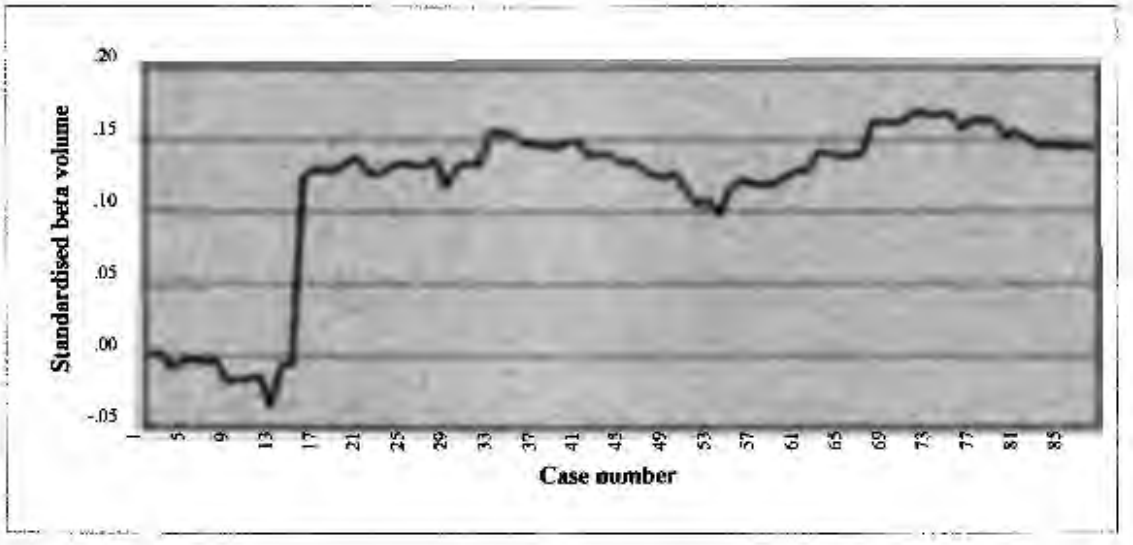
Graph of the standardised beta of the term structure of interest rates risk factor vs time



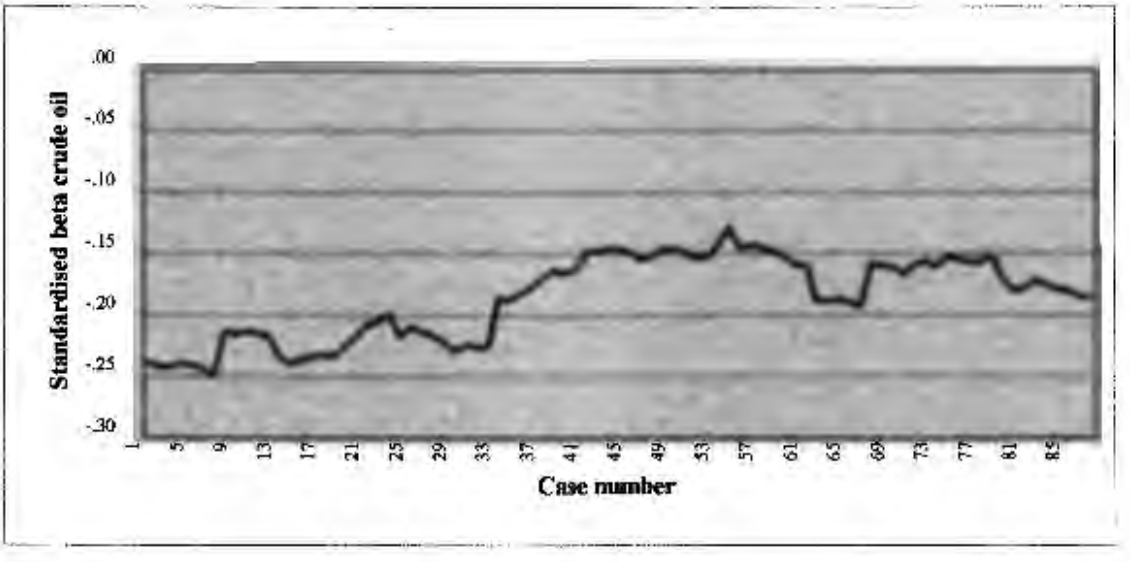
Graph of the standardised beta of the bankers' acceptance rate risk factor vs time



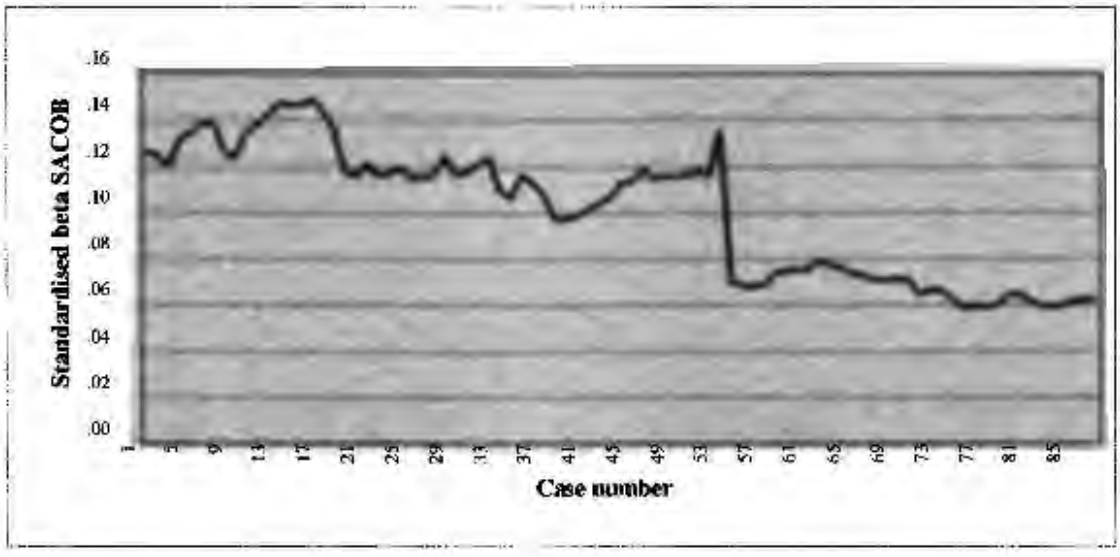
Graph of the standardised beta of the dividends risk factor vs time



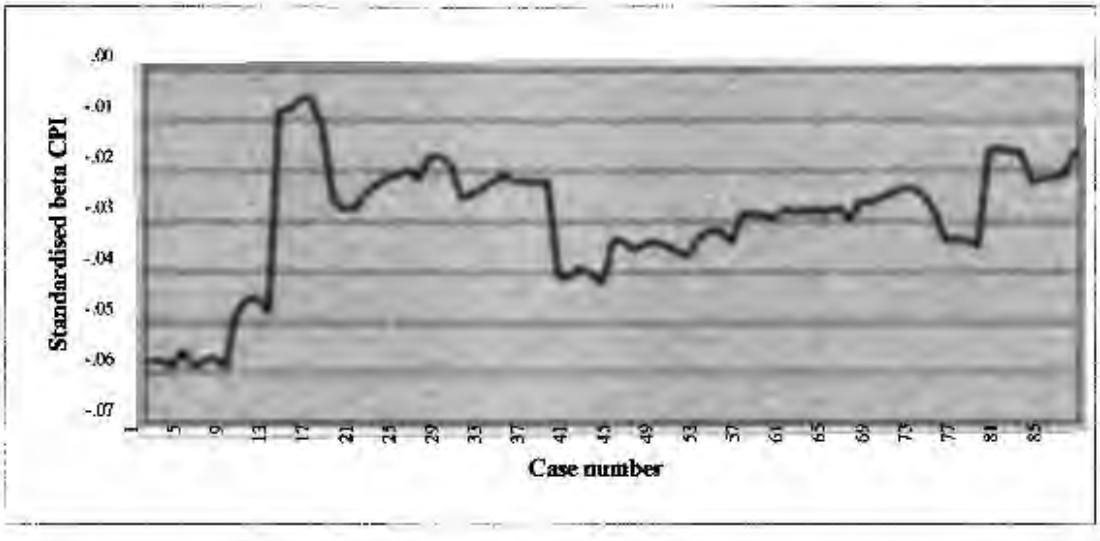
Graph of the standardised beta of the volume of shares traded risk factor vs time



Graph of the standardised beta of the crude oil risk factor vs time



Graph of the standardised beta of the SACOB business confidence index risk factor vs time



Graph of the standardised beta of the term CPI risk factor vs time

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