theory and common sense'.

According to the Fisherian theory of interest, nominal rates can expressed as the sum of the real rate of interest and the expected inflation rate. Contrary to this theory, Fama and Schwert (1977:144) report the share returns are negatively related to expected inflation rates, unexpected inflation rates and to changes in expected inflation rates.

Fama (1981:545) argues that the negative relationship between inflation and share returns is spurious, as inflation is negatively related to future economic activity and share returns are positively related to future economic activity. Fama (1981:549) provides a theoretical justification using money demand theory. He states that a decline in expected real activity lowers the demand for real money, which given a nominal money supply and interest rate, will be accommodated by an increase in the price level\textsuperscript{67}. Fama (1981:563) reports that the empirical tests of this theory are successful.

Ceske and Roll (1983:3-4) correctly point out that the argument set out above is one of the only explanations that appears to be logical and consistent with rational economic behaviour. They, however, argue that there are two problems with the theory:
- the magnitude of the effect is insufficient to explain the observed negative relationship; and,
- the money demand theory ascribes a purely passive role to government.
While generally they support the money demand theory, they argue that this theory will not provide a pure explanation and their theory compliments that of Fama (1981).

Geske and Roll (1983:6) argue that share returns signal changes in inflation due to the following process. When share returns change in response to an

\textsuperscript{67} Fama (1981:549) makes the assumption that inflation is caused by real activity.
economic shock, this indicates that income will change (in the same direction). This in turn will have an impact on government revenue. Thus government revenue and share returns will be closely related. To the extent that government expenditure is "fixed" and deficits occur, the government will be required to borrow. Geske and Roll (1983:6) argue that the US government has "monetize[d]" the debt and caused the money supply and thus inflation to increase. The practice of monetization is anticipated by investors and so expected inflation will increase. Geske and Roll (1983:29) state that every (empirical) link within this process is in place and there is supporting evidence in every case.

5.3.3.1.3 INTEREST RATES

Interest rates impact upon share returns in at least two ways:
- firstly, the rate of interest is the opportunity cost of holding money and as such will impact on share returns as investors vary their cash balances and proportion of bonds to equity in their portfolios; and,
- there is a negative relationship between interest rates and investment. Higher rates imply lower current investment and thus lower future income.

Investors will form expectations of interest rates and will behave accordingly. These expectations will be reflected in the term structure of interest rates.

Estrella and Hardouvelis (1991:555) report that empirical work indicates that the slope of the yield curve correctly predicts the direction of changes in future spot rates. In addition, the term structure appears to predict real economic activity. The causation is as follows: consider a shock to the economy that causes short term rates to rise, but leaves long term rates relatively unchanged. This would cause previously profitable investment opportunities to be abandoned, as a consequence, future real economic activity will decline. Thus a flattening of the yield curve indicates a decline in future income.

Estrella and Hardouvelis (1991:574) present evidence that the slope of the yield
curve can predict cumulative changes in real economic output four years into the future. This finding is consistent with that of Fama (1990:60) who states that yield spreads contain information about expected values of a "range of economic variables", although these spreads only provide "noisy forecasts". Fama (1990:66-67) is able to show that the yield spread is able to forecast changes in one year inflation rates and the real return on bonds over one and two years, but not the spot interest rates.

It appears that the term structure is a "jack-of-all-trades" (Fama 1990:73) it captures a great deal of information that is useful in determining share returns.

5.4 APT AND CAPM

It is obvious that researchers would compare and contrast the CAPM and the APT. In this section, we review some of the studies that have been conducted into the topic. The first question of interest revolves around the explanatory power of the alternate approaches. The next question considers whether or not the CAPM-β is a "consensus" measure of risk. The third question, probably the most important, is whether the various anomalies (reviewed in the last chapter) persist in an APT environment. As we shall see, the APT stands up to the tests rather well.

5.4.1 APT VERSUS CAPM

Given that the APT is a competitor model to the CAPM, it is necessary to determine whether or not the data favours the APT or the CAPM. It is this very question that Chen (1983) considered.

Using daily returns for the period 1963-1978, he prespecifies a five factor APT model using odd days - the even days data are used to test the model. In order to tests whether the data favours the CAPM or the APT he specifies the
following model:
\[
    r_i = \alpha_r^\text{APT} + (1 - \alpha) r^\text{CAPM}
\]
where: \( r_i \) = the actual return;
\( r^\text{APT} \) = expected return generated by the APT; and,
\( r^\text{CAPM} \) = expected return generated by the CAPM.
If the data favours the APT, the point estimates for \( \alpha \) will unity. Chen (1983:1401) reports that this is indeed the case, although the t-tests often indicate that the estimates are significantly different from one. Chen (1983:1401) argues that a theoretically superior test is suggested by Bayesian analysis. Accordingly he calculates posterior odds ratios for the CAPM and APT and reports that, with one exception, the ratios are overwhelmingly in favour of the APT.

It appears that in the acid test, ie. does the APT have more explanatory power than the CAPM, that the APT performs well. This is corroborated by Roll (1988).

Roll (1988) investigates the explanatory and predictive power of asset pricing theories. Using monthly returns for the period 1982-1987, Roll (1988:543-544) estimates the \( R^2 \) for the CAPM and the (five factor) APT. He reports that the mean \( R^2 \) for the CAPM is 0.179 and for the APT is 0.244. It can be seen that the explanatory power of the APT is greater than that of the CAPM, but is still modest.

5.4.2 BETA AS A CONSENSUS RISK FACTOR

Roll and Ross (1980:251) have argued that financial economists often confuse the APT and CAPM - thinking of the CAPM as a one factor APT model. Shanken (1985:1189) suggests that the converse is also true, "in many discussions of the APT, scholars ... [are] thinking of a multibeta interpretation of the CAPM". It is easy to fall into this mode of thinking.
The CAPM-β is a measure of sensitivity to movements in the market portfolio. If the APT is true, then the k-factors will impact on the shares in the market portfolio and the share under consideration. The resulting CAPM-β for that share will be an aggregated estimate of the k-factors impact on the stock. Born and Moser (1988:290-291) introduce this type of argument to show that the market factor cannot be an APT factor, unless it is the only factor. Thus, if evidence is found that the market factor is priced in addition to other factors, then the empirical specification is underspecified.

The basis of their argument is as follows:
Recall (3.15): \( \sigma_i^2 = \beta_i^2 \sigma_m^2 + \sigma_e^2 \)

Similarly the \( \sigma_i^2 \) of returns under the APT can be described as follows:

\[ \sigma_i^2 = \sum b_j^2 + \sigma_e^2 \]

where \( b_j^2 \) = sensitivity of asset i's return to risk factor j.

If we define the return on the market portfolio as \( r_m = \sum w_i r_i \), then we can derive the following expression:

\[ r_m - E(r_m) = \sum w_i \delta_j + \sum w_i \epsilon_i \]

where \( w_i \) = the wealth relative weight of asset i in the market portfolio.

Now define \( b_j \) as a wealth weighted average of sensitivity to risk and (5.8) reduces to: \( r_m - E(r_m) = \sum b_j \delta_j + \sum w_i \epsilon_i \).

This implies that unexpected changes in the return on the market portfolio results from and is explained by unexpected changes in the APT factors. If the APT is true, the market portfolio must (by definition) be "driven" by these factors and only these factors. A market factor (CAPM-β) is redundant information. The Born and Moser (1988:291) argument, in essence, is as follows: the CAPM and APT assume similar return generating processes at different levels of aggregation. The CAPM-β is merely an average of the APT factors.

If the view that the CAPM-β is a consensus factor is correct, then Born and
Moser (1988:295) argue that \( \beta \) can be "decomposed" into its constituent factor prices. If this decomposition process gives rise to more than one factor, then we can argue that there is more than one return generating factor. This is evidence that will allow us to reject the CAPM.

In order to test this hypothesis, Born and Moser (1988:295-297) calculated factor loadings on six factors (using principal component analysis) for the thirty stocks that comprise the Dow Jones Industrial Index in the period 1962-1982. They then regressed the factor loadings against the corresponding \( \beta \)'s and found evidence that \( \beta \) is a "consensus" risk factor. At the five per cent significance level they report that three factors are priced and at the ten per cent level an additional factor is "priced" (Born and Moser 1988:297).

5.4.3 APT AND CAPM ANOMALIES

As it has been argued that the CAPM is misspecified (due to the anomalies that have been associated with it), it is useful to consider whether or not these anomalies are found within the APT. Reinganum (1981:313) has argued that there is no justification for embracing the APT if it cannot "convey any more information than does the [CAPM]."

5.4.3.1 JANUARY EFFECT

Gultekin and Gultekin (1987) test the APT in order to determine its sensitivity to the January effect. Using daily data drawn from the CRSP tapes for the period 1962-1981, they replicate the Roll and Ross (1980) methodology to determine factors and factor loadings. Gultekin and Gultekin (1987:1219) report that the mean return for stocks is highest in January and November. They also calculate factor loadings for every month and report that risk premia are always significant in January, but not in non-January months. Thus they argue that the APT, like the CAPM, has a January phenomena.
Cho and Taylor (1987) perform a similar analysis in order to test the stability of the number of factors and the pricing of factors on a monthly basis. Their sample consisted of daily returns for the period 1973-1983, also drawn from the CRSP tapes. Portfolios were constructed on the basis of industry, size (market value) and on a random basis.

Cho and Taylor (1987:1205) calculate the number of factors using maximum likelihood factor analysis (for each month). They report (Cho and Taylor 1987:1206) that the number of factors range between four and ten (averaging at between six and seven). In addition, there is evidence of wide fluctuations in the number of factors across portfolio groups and calendar months. There appear to be more factors in January and September for random portfolios, in October for industry portfolios and September for size portfolios.

When testing pricing relationships, Cho and Taylor (1987:1208) report that the APT does not hold for the entire period. They argue, however, that January is different from the other months as there is some evidence that at least one factor is priced.

The difference between this study and the Gul Tekin and Gul Tekin (1987) study is that Cho and Taylor (1987) do not use the same prespecified factor structure for every month, but reestimate it for each month. Despite this difference the results are similar, yet Cho and Taylor (1997:1210) urge against hasty conclusions. They argue that the methodology used to test the APT is weak and that researchers should be cautious in drawing conclusions about any APT-January effects.

Chang and Pinegar (1990:518) argue that a potential reason for anomalous findings such as the January effect, could be a failure to correctly identify sources of systematic risk. They make use of the Chen, Roll and Ross (1986) factors to investigate the January effect. Specifically, they investigate the following issues:
- are the risk factors stationary across time?; and,
if not, are risk factors significant in non-January months? (Chang and Pinegar 1990:518).

Using monthly holding period returns on twenty size ranked portfolios and the Chen, Roll and Ross (1986) macroeconomic variables for the period 1958-1984, Chang and Pinegar (1990:525-526) report that risk premia are non-stationary, not only the price of risk but the risk estimates are nonstaticnary. Chang and Pinegar (1990:528) further report that there are significant non-January risk premia, notably industrial production and changes in expected inflation (the latter is not priced in January).

Chang and Pinegar (1990) find that APT risks are incurred in non-January months, but not necessarily all simultaneously. The Chen, Roll and Ross (1986) risk premia are able to explain forty six per cent of the variation in returns. Thus, Chang and Pinegar (1990:528) argue that these risk premia provide a more fundamental insight into the return generating process than do more "traditional" tests of the CAPM and APT. It is this that provides a partial explanation as to why previous studies have not detected a non-January risk-return relationship, the various sources of risk are not equally priced throughout the year and the lack of risk premia in previous studies may be as a result of "countervailing influences" in the data (Chang and Pinegar 1990:532). Chang and Pinegar (1990:532) conclude that the notion that there is no reward for systematic risk in non-January months needs to be reconsidered.

5.4.3.2 FIRM SIZE EFFECT

Reinganum (1981b) provided one of the earliest tests of the APT in the area of CAPM anomalies. Using daily data drawn from the CRSP tapes for the period 1963-1978, Reinganum (1981b:315-316) randomly assigns stocks to thirty equally weighted portfolios and estimates three-, four-, and five-factor models.
He uses these factor models to calculate expected values for each stock and so calculates a residual (Reinganum 1981b:316-317). Each stock is then assigned to a portfolio on the basis of size and the portfolio residual is calculated. Reinganum (1981b:318) reports that the residual for the smallest size portfolio is positive and the residual for the largest size portfolio is negative. This is interpreted as evidence against the APT as a size effect persists even after APT risk has been accounted for.

Chen (1983:1408-1409) also considers the size effect in his comprehensive comparison of the APT and CAPM. Using data provided by Reinganum, he separates firms into two groups; small and large. He then makes use of a mathematical programming technique to form two portfolios that have the same factor loadings. Paired t-statistics are then used to compare returns for each of the portfolios. Chen (1983:1409) reports that he is unable to reject the null hypothesis of firm size having no explanatory power after an APT risk adjustment. Unfortunately, Chen (1983) offers no explanation for the discrepancy between his results and Reinganum (1981b).

Chan, Chen and Hsieh (1985) investigate the size effect using the Chen, Roll and Ross (1986) macro-factors. Chan, Chen and Hsieh (1985:456) form twenty portfolios ranked by size and then regress the portfolio returns on the macro-factors. They constrain the intercept terms and risk premia to be the same in each case. Thus if there is a size effect it will be evident in the residuals. Chan, Chen and Hsieh (1985:460) report that while the pattern of the residuals resemble a size effect, that the magnitude is so small that "it is doubtful whether any risk-adjusted profits can be realized in practice".

Chan, Chen and Hsieh (1985:470) conclude that the size effect is captured by the AFT and that the higher return associated with small firms is "justified by the additional risks borne in an efficient market". Thus it appears that the APT is able to explain some of the anomalies that are associated with the CAPM. This in itself makes the APT a superior model to the CAPM.
5.5 THE APT AND THE JOHANNESBURG STOCK EXCHANGE

To date there have been two published empirical studies on the APT in SA. Page (1986) was the first researcher to publish empirical results on the APT. He replicated the Roll and Ross (1980) methodology. Making use of one hundred and twenty stocks, he calculated weekly and monthly returns (price only) for the period 1973-1982. Shares were then randomly assigned to one of four portfolios and principle component analysis carried out (Page 1986:39-40).

Two tests were employed to determine the number of significant factors. The "scree test" shows three factors to be significant (a visual inspection of the diagrams (Page 1986:41) reveals that the first eigenvalue tends to be large compared to later eigenvalues). A cross sectional regression, however, only identifies two priced factors (Page 1986:40).

Page (1986:40) then tests a two-factor APT model against the SML-CAPM and the market model. Page (1986:41) reports that the APT appears to explain a considerably larger percentage of returns than does the CAPM or market model. The average $R^2$'s are 0.266 for the CAPM, 0.113 for the market model and 0.394 for the APT.

Page (1986:42) clearly favours a two-factor APT model over the CAPM, but does not identify the nature of the factors. He does refer to Gilbertson and Goldberg's (1981) two-factor market model and argues that argues that the underlying macro-factors can be divided into those that effect mining and those that effect the industrial sector.


\(^{18}\) It is not stated whether the returns include dividends or not. Given the nature of the indices it is unlikely.
calculated for the period 1978-1987. Macro-economic data was taken from the Standard Bank ECOCATS data base (Barr 1990:20). It should be noted that Barr (1990) does not make use of unexpected changes in the macro-variables - he appears to use just the changes. This theoretical error introduces a potential bias into the consequent results.

By making use of a covariance biplot method, Barr (1990, 21-25) demonstrates that the first priced factor is an "industrial index" and that the second factor is a "financial" factor. The economic forces driving these factors are gold and interest rates for the first factor and foreign markets and local confidence for the second.

This then is the state of the art in SA. Page (1986) has shown two priced factors and Barr (1990) has (tentatively) identified them. As indicated this latter study is theoretically unsound and until validated, the results should be viewed with circumspection. In no way can it be said that the APT has been extensively tested as it has been in the US.

5.6 CONCLUSION

In this chapter, we have reviewed the theory and evidence pertaining to the APT. We have seen that the empirical problems associated with testing the theory do not make it a simpler theory to test vis-a-vis the CAPM. It does avoid many of the anomalies associated with that theory. Within the JSE, where the CAPM anomalies are absent, this is not an inherent advantage.

Given the limited research into the APT that has occurred on the JSE, it is necessary to conduct an empirical investigation into the APT and determine whether it fares better than the CAPM.
CHAPTER SIX

EMPIRICAL TESTS OF THE APT

"Its modest assumptions and its pleasing implications surely render the APT worthy of being the object of empirical testing" Roll and Ross (1980:245).

In this chapter some of the empirical tests discussed in the previous chapter will be replicated using JSE data. The purpose of this chapter is to provide some empirical content to the theory of arbitrage pricing in the JSE. An exploratory factor analysis will be conducted to determine the number of factors that should be used in an APT model. The "classic" Chen, Roll and Ross (1986) paper is then replicated with South African data. The impact of the dollar price of gold on JSE returns is then considered. A conclusion follows a general discussion of the empirical relevance of the APT to SA.

6.1 AN ENDOGENOUS APPROACH TO APT

In this section the endogenous approach to estimating the APT will be applied. Following the early studies of the APT, factor analysis was employed to estimate the number of factors. The following tests were replicated:
- Roll and Ross (1980);
- Trzcinka (1986);
- Born and Moser (1988); and,
- as a by product of Roll and Ross (1980), Scree tests were performed.

6.1.1 ROLL AND ROSS (1980)

The Roll and Ross (1980:256-257) methodology was employed (with a few modifications). They made use of forty two portfolios, each containing thirty securities in order to estimate the factors - maximum likelihood factor analysis was employed in that study.
In this study, due to data limitations, (Roll and Ross (1980) were able to use one thousand two hundred and sixty stocks in their analysis), seven portfolios were constructed on an alphabetical basis. The first three portfolios consist of fifty stocks each for the first five year period. The final four portfolios come from the second period, three of the portfolios contain fifty stocks and the final portfolio contains forty eight stocks. The reason for the increase in the portfolio size over the Roll and Ross (1980) study is that the portfolios should be well diversified (Chamberlain 1983:1312-1315) when performing the factor analysis - we saw in an earlier chapter that such a portfolio should contain approximately fifty stocks in order to reduce second order risk.

Unlike Roll and Ross (1980:257) the factor analysis was performed on a correlation matrix and not a covariance matrix as the nature of the investigation was exploratory. Kim and Mueller (1978b:76) argue that when the objective of the study is exploratory it makes no difference whether or not the correlation or the covariance matrix is used, but when the variances of the variables are not equal, "[i]t is ... advisable to use a correlation matrix". Thus it seems appropriate that when considering share returns that a correlation matrix be used.

The procedure was as follows:
- for the first period (1981-1985) three fifty share portfolios were constructed in alphabetical order;
- factor analysis\textsuperscript{69} was performed on each portfolio;
- a "scree" test was performed on the eigenvalues (see figure 6.1)\textsuperscript{70};
- the individual factor scores were used to explain average returns for the

\textsuperscript{69} Maximum likelihood factor analysis with varimax rotation was employed.

\textsuperscript{70} This figure only contains the results of two of the scree tests, the first is portfolio one (1981-1985) and the second is portfolio four (1986-1990). As all the scree are identical with a turning point at three eigenvalues, it was felt to be unnecessary to show all seven.
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