The Arbitrage Pricing Theory in South Africa: An empirical study of the effect of pre-specified risk factors on share prices on the Johannesburg Stock Exchange.

BY:

BERNADINE KATHLEEN REESE

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ABSTRACT

This study tests the Arbitrage Pricing Theory on the Johannesburg Stock Exchange (JSE). Following the McElroy and Burmeister (1988) approach of pre-specifying a factor structure to be tested, a possible set of factors was selected on the basis of a priori theoretical and empirical evidence that they could affect share prices. All combinations of these factors were separately tested against mining and industrial shares listed on the JSE.

Two sets of tests were performed, firstly, a multivariate nonlinear regression with cross-equation restrictions as a test of the APT model and secondly, a seemingly unrelated regression model.

The APT test results for mining shares show 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. Two one-factor models yielded priced APT factors. These were the model including the gold price risk and another model with growth rate risk. Whilst these were both priced APT factors, the gold price risk model was better fitted.

Four models were selected from the APT tests on industrial shares, on the basis of high adjusted-R^2 values and factors which were significantly different from zero. They included 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.

The seemingly unrelated regression models had very similar adjusted-R^2 values and indicated that the APT did not appear to explain the variation in share returns any better or worse than the seemingly unrelated regression model.

The adjusted-R^2 values for individual shares and the signs of the factor risk-premiums appear to be reasonable. The residual market risk factor was significantly different from zero for both the mining and industrial share samples, indicating that further work is required to identify the APT factors operating on the JSE.

DECLARATION

I hereby declare that, unless specifically indicated to the contrary, this thesis is entirely my own work and is fully referenced.

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> "At best, perhaps factor analysis can be used to confirm a prespecified factor structure. Economic theories should provide a better understanding of a meaningful factor structure than does explanatory factor analysis. The current trend of prespecifying the factors seems to be a more promising avenue of research in the search for a stable and meaningful factor structure" (Conway and Reinganum, 1988, 15).

The pricing of the returns on risky assets continues to attract considerable interest from finance researchers. Several models have been proposed to improve the understanding of this process, although only two have received substantial attention, namely the Capital Asset Pricing Model (CAPM) and the Arbitrage Pricing Theory (APT). Although the CAPM of Sharpe (1964) has enjoyed widespread use and acceptance, academic disenchantment reviewed by Seneque (1987), has been growing steadily over the past two decades. As a result the Arbitrage Pricing Model, developed by Ross (1976), has been accepted by many researchers as a more testable and less restrictive successor to the CAPM.

Empirical testing is essential to the APT because the theory itself is very general. Whilst it states that several risk factors may affect returns, neither the number nor nature of these factors are specified. Testing is required to identify these factors so that the APT can be used in practical applications such as portfolio management.

The first tests of the APT involved factor analysis - a statistical method that appears to be fraught with problems. An alternative method, originally proposed by Chen, Roll and Ross (1986) involves prespecifying a set of observed factors and then testing for them.

McElroy and Burmeister (1988) used a more advanced statistical technique in testing for priced factors in the US market and a similar approach is adopted in this study.

The APT is an intuitively appealing theory because it allows the number of risk factors to be more than one and does not specify that the risk factors are purely related to the market as the CAPM does. There has been limited research using the APT on the JSE, particularly relating to determining the nature of the factors. This study was undertaken to attempt to identify possible priced APT factors to make the theory more useful for practical applications such as forecasting and portfolio management decisions.

The following chapter structure is adopted. Chapter 2 discusses the development of the APT based on the assumption that a linear return generating process is used to explain actual returns. Under a "no arbitrage" condition, a mathematical expression for the return on a risky asset is then developed. The relevant literature is reviewed in Chapter 3, concentrating on the studies which tested for a pre-specified set of observable factors. Chapter 3 also details and compares the statistical methods used in previous studies. The choice of statistical method for this study is motivated and its advantages are discussed. A suggested set of observable factors is presented in Chapter 4 and theoretical and empirical support is provided for the inclusion of each factor. The factors specified are: foreign exchange risk, default premium risk, inflation rate risk, gold price risk, the term structure of interest rates risk, growth rate risk and residual market risk. The variables used to measure the factors are also noted.

Chapter 5 examines the data requirements of the study and, in particular, the shares to be included in the samples. A separate test of the mining and industrial sectors is also motivated.

Chapter 6 details the two methodologies to be used, namely McElroy and Burmeister's (1988) APT model and a seemingly unrelated regression model. The results of the tests of the APT and a comparison with results that are based on a seemingly unrelated regression model, are presented in Chapter 7. A review of the results, conclusions and directions for future work are presented in Chapter 8.

CHAPTER 2: THE ARBITRAGE PRICING THEORY

2.1 Introduction

Formulated by Ross (1976), the arbitrage pricing theory is a more generalised and less restrictive theory than its predecessor for the pricing of risky assets - the Capital Asset Pricing Model.

2.2 Assumptions of the APT

There are three major assumptions underlying the development of the model:

1. Capital markets are perfectly competitive.
2. Investors always prefer more wealth to less wealth, with certainty.
3. The process that generates asset returns can be represented by a K-factor model of the form:

$$r_{it}-E_t[r_{it}]=\sum_{j=1}^{J} b_{ij}f_{jt}+\epsilon_{it} \qquad (2.1)$$

for i=1,....N an› t=1,....T.

where: r_{it} = total return on the ith asset in period t;
$E_t[r_{it}]$ = expected return on the ith asset for period t as expected at the beginning of period t;
f_{jt} = the jth factor in period t;
b_{ij} = the sensitivity of asset i to factor j;
ϵ_{it} = a random error term specific to the ith firm.

In addition, $E(f_j) = 0$ (the expected return on the factors is zero), $E(\epsilon_i) = 0$, $E(\epsilon_i\epsilon_j) = 0$ for all i and j (residuals are uncorrelated) and all factors must be uncorrelated with the random error term, ie. $E(\epsilon_i f_j) = 0$ for all i and j (Francis, 1986).

The latter two assumptions are in accord with a common sense perception of how financial markets work. The first describes the theoretical perfect market in which no arbitrage opportunities[1] exist. Whilst a model should be judged on how well it explains real-world phenomena and not on the basis of it assumptions, this accordance with common sense gives the model intuitive appeal.

2.3 Derivation of the APT

A brief derivation of the APT model can be given by considering the return on a portfolio (w_1, ... w_N), can be given by:

$$r_{pt}=\sum_{i=1}^{N} w_i r_{it}=\sum_{i=1}^{N} w_i\,[E_t(r_{it})+\sum_{j=1}^{J} b_{ij}f_{jt}+\epsilon_{it}] \qquad (2.2)$$

$$=\sum_{i=1}^{N} w_i E_t(r_{it})+\sum_{i=1}^{N}\sum_{j=1}^{J} w_i b_{ij} f_{jt}+\sum_{i=1}^{N} w_i \epsilon_{it} \qquad (2.3)$$

where: r_{pt} = return on a portfolio in time period t;
w_i = portfolio weighting for share i for the time period t;
r_{it} = return on share i in time period t.

If the portfolio is well-diversified then based on the strong

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[1] An arbitrage opportunity can be defined as "a perfectly hedged portfolio that can be acquired at a cost of zero, but that will have a positive value with certainty at the end of the investment period" (Francis, 1986, 867).

law of large numbers, it is reasonable to assume that:

$$\sum_{i=1}^{N} w_i \epsilon_{it} = 0 \qquad (2.4)$$

so that the return on the portfolio can be represented as follows:

$$r_{pt} = \sum_{i=1}^{N} w_i E_t(r_{it}) + \sum_{i=1}^{N} \sum_{j=1}^{J} w_i b_{ij} f_{jt} \qquad (2.5)$$

Under the assumptions of "no arbitrage", a zero net investment in a risk-free portfolio should yield a zero return, that is: a zero net investment:

$$\sum_{i=1}^{N} w_i = 0 \qquad (2.6)$$

in a riskless portfolio, given by:

$$\sum_{i=1}^{N} w_i b_{ij} = 0 \qquad (2.7)$$

for j=1, ... J.

implies that the portfolio should yield a zero return, given by:

$$r_{pt} = \sum_{i=1}^{N} w_i r_{it} = 0 \qquad (2.8)$$

From equation 2.5, this implies that

$$r_{pt}=\sum_{i=1}^{N} w_i E_t(r_{it})=0 \qquad (2.9)$$

Multiplying (2.6) by a constant, λ_{0t} and (2.7) by a constant λ_{jt}, and then adding, one obtains:

$$\sum_{i=1}^{N} w_i(\lambda_{ot}+\lambda_{1t}b_{i1}+\ldots\ldots+\lambda_{jt}b_{ij})=0 \qquad (2.10)$$

Now since for a no-arbitrage portfolio

$$\sum_{i=1}^{N} w_i E_t(r_{it})=0 \qquad (2.11)$$

one can obtain, on equating (2.10) with (2.11) that:

$$E_t(r_{it})=\lambda_{ot}+\lambda_{1t}b_{i1}+\ldots\ldots+\lambda_{jt}b_{ij} \qquad (2.12)$$

Under the basic assumptions of the APT the expected return can thus be explained in terms of the risk-free rate[2] and the sensitivity of each asset to the risk-premiums of each factor:

$$E_t(r_{it})=\lambda_{ot}+\sum_{j=1}^{J} b_{ij}\lambda_{jt} \qquad (2.13)$$

where: i=1,...N and t=1,....T.
λ_{0t} = the risk-free rate of return in period t;
λ_{jt} = the risk-premium of factor j in period t.

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[2] Letting r_{ft} denote the rate of return on a risk-free asset, substitution into equation (2.13) will yield

$$E(r_{ft}) = \lambda_{0t}$$

Thus being a risk-free asset we have $r_{it} = E(r_{ft}) = \lambda_{0t}$. If there is no risk-free asset, λ_0 can be used to denote a "common return on all zero beta assets (assets having b_{ij}=0 for all j)" (Page, 1986, 39).

The risk-return relationship explained by the APT is a function of the risk-premium of each factor. The parameter λ_{jt} is the premium or discount earned by an investor for assuming one unit of risk from the jth factor for period t, given zero sensitivity to the other factors.

The magnitude of the impact of a particular factor on a share's expected return is a function of the sensitivity of the share to the factor and the factor's risk-premium. The higher the beta coefficient, the greater the impact of the factors on the share's expected returns. The factor betas are established by testing and in portfolio management decisions, they are thus known in advance and determine the effect of the risk-premium on expected returns.

The risk-premiums are assumed to be constant for the market and do not vary from share to share, as the sensitivities do.

2.4 Summary

The APT states that the expected return on a risky asset is a function of the risk-free rate and the asset's sensitivity to the risk-premium of several factors affecting returns.

Although expected returns incorporate anticipated changes in these variables, actual returns will differ due to risk factors or unanticipated movements in the variables. Thus, these variables, the exact number and nature of which are unspecified by APT, are a primary determinant of returns on assets.

CHAPTER 3: A REVIEW OF APT LITERATURE

3.1 Introduction

There is a wealth of literature relating to tests of the number of APT factors. Since the seminal article published by Roll and Ross (1980), numerous tests have been performed on various world stock markets. This work is characterised by the almost exclusive use of factor analysis as a testing method.

To date, conflicting results have been obtained, largely as a result of problems inherent in the statistical method of factor analysis. Whilst the number of factors has not been determined with accuracy, an estimate obtained by Roll and Ross (1980) for the US market (possibly three to four factors) appears to be sufficiently low to be reasonable.

Chen, Roll and Ross (1986) attempted to identify a set of factors without using factor analysis. This involved testing a pre-specified set of factors using regression analysis. Subsequent studies have been performed, mainly in the US markets with considerable support for the results obtained by Chen et al.

In South Africa, published empirical work has been largely limited to a study by Page (1986) which used factor analysis to identify the number of factors affecting share returns on the JSE.

This chapter reviews some of the major studies of the approach that pre-specifies a set of factors. A brief overview of the factor analysis based approaches is also given.

3.2 Factor analysis approaches

3.2.1 Studies of the US market

The Roll and Ross (1980) study laid the testing groundwork for subsequent work. Data was drawn from security returns on the New York (NYSE) and the American Stock Exchanges (AMEX) from July 1962 to December 1972. 1260 securities were selected for examination and subdivided into 42 groups of 30 each. Factor analysis was then used to determine the number of common factors.

Two tests were undertaken; the first specifying the risk-free rate and the second allowing it to be estimated by the model. The results indicated that it was probable that "at least three factors are important for pricing, but it is unlikely that more than four are present" (Roll and Ross, 1980, 1092). Thus, these results were supportive of a multi-factor model and the APT in general. This initial study has been followed by many other tests. Most notable were: Brown and Weinstein (1983), Kryzanowski and To (1983), Bower et al. (1984), Pari and Chen (1984), Trzcinka (1986) and Conway and Reinganum (1988).

Factor analysis and the problems it introduces to testing, particularly relating to the number of observations and the sample sizes, were discussed at length by Dhrymes, Friend, Gultekin and Gultekin (1984). This paper resulted in further debate between Roll and Ross, and Dhrymes et al. (1985).

3.2.2 South African studies

Tentative estimates of the number and nature of factors in United States markets has been established by research. However, South African and American markets are not necessarily comparable. Economic sanctions and disinvestment during the 1980's reduced South Africa's economic integration with the rest of the world. So, South African asset markets could be affected by a different number of factors, possibly representing different economic forces.

South African research on the number and nature of APT factors is limited. There appear to be only two published articles, those of, Page (1986) and Seneque (1987).

Page (1986) used share price data for 200 companies, quoted on the Johannesburg Stock Exchange (JSE) between January 1973 to January 1982, to extract a factor structure. Factor analysis indicated that there were two priced factors. These emerged consistently in each of the four groups tested. Whilst this indicated a two-factor model, Page (1986, 42) concluded that "the possibility of more 'priced' factors cannot, however, be excluded with certainty". His results indicated that the two factors are somehow related to the mining and industrial sectors. This result is supported by Gilbertson and Goldberg (1981). Although not testing the APT, the authors determined that "the fortunes of the two sectors can at times be influenced by quite different factors" (Gilbertson and Goldberg, 1981, 42).

The market returns on the sectors are not factors per se. Rather, there appear to be two specific variables or two classes of macroeconomic variables which affect share returns in the two sectors differently. Mining share returns appear to be more sensitive to some of the variables whilst industrial share returns appear to be more sensitive to the other variables. For example, the returns on gold shares appear to be fundamentally affected by the gold price. Whilst the gold price may also affect the returns on industrial shares, the sensitivity coefficients (b's) should be lower. The exact number or nature of these factors has not been determined and further research is required to identify them. Thus, three or four priced factors have been identified in the US markets and two factors on the JSE. The problems associated with the use of factor analysis in these studies led to another testing approach, namely that of testing a pre-specified set of factors.

3.3 Tests of a pre-specified observable set of factors

3.3.1 Chen, Roll and Ross (1986)

In a seminal paper for this approach, Chen, Roll and Ross (1986) pre-specified a set of factors to include in their model and then tested whether the selected factors were priced by the APT.

The method is a derivative of the Fama-MacBeth (1973) technique used to test the CAPM. It is informally known as the "two-step" method because step one estimates the asset sensitivities to the factors (betas) which are used in step two to estimate the factor risk-prices, (λ's).

In step one, an asset's exposure to each of the economic factors was estimated by regressing the asset's returns against the unexpected changes in the set of factors over some period of time (in this case the previous 5 years). To control the errors-in-the-variables problem that may result from the first step, the assets were then grouped into portfolios on the basis of firm size. This should diversify away any unsystematic risk in the asset's returns so that it would not affect further analysis. The portfolio betas from step one were then used as input (independent variables) for 12 cross-sectional regressions (1 per month) with the asset returns being the dependent variables. This regression yielded estimates of the risk-premium of each factor. The above procedures were then repeated for each year in the sample to yield a time series of estimates for the risk-premiums. Finally, t-tests were used to test whether the risk-premium estimates were significantly different from zero. The test was conducted on share returns for the period January 1953 to November 1983. Results indicate that several of the factors were significantly different from zero. Most important were unanticipated changes in the following variables: industrial production, the default premium, the term structure of interest rates (changes or "twists" in the yield curve) and inflation. However, it was difficult to measure these factors since there are problems in distinguishing between anticipated and unanticipated changes in the variables.

3.3.2 **Burmeister and Wall (1986)**

The study re-examined the four factors proposed by Chen, Roll and Ross (1986). The sample period covered was December 1971 to November 1981. Ordinary least squares regression analysis was used to estimate the risk-premium for each factor. Two tests were performed: one using a constant risk-free rate and the other estimating the risk-free rate from the regression analysis. The results of the two tests did not differ significantly.

However, the results indicated that these factors did not adequately explain the discrepancy between actual and expected returns. So, Burmeister and Wall attempted to identify another factor that might explain the remaining variance. This was achieved by creating what has become known as a "residual market risk factor" (Berry, Burmeister and McElroy, 1988, 29). It can be defined as the unanticipated change in the market index not explained by the pre-specified macroeconomic factors.

t-tests were performed to determine the effect of the factors on individual shares as well as portfolios. All five factors were important determinants of return. Together they explained 82% of return on a portfolio of 20 randomly selected shares.

3.3.3 McElroy and Burmeister (1988)

Given that:

$$r_{it}=\lambda_{0t}+\sum_{j=1}^{J} b_{ij}\lambda_j+\sum_{j=1}^{J} b_{ij}f_{jt}+\epsilon_{it} \tag{3.1}$$

defines the return on an asset in an APT framework, McElroy and Burmeister (1988) use a nonlinear iterative estimation technique similar to the one that has been developed by Gallant (1975) to allow for the joint estimation of the b's and the asset risk-premiums. Given that the factors are observable, the factor sensitivities and risk-premiums in (3.1) can be estimated in three steps, as follows.

1. Firstly ordinary least squares (OLS) regression techniques are applied to (3.1) on a share-by-share basis, to yield estimates for $\{b_{i1}\lambda_1, \ldots\ldots b_{ij}\lambda_j\}$.
2. The OLS residuals from fitting (3.1) 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 as follows:

$$S=T^{-1}\sum_{k=1}^{T} e_{ik}e_{jk} \tag{3.2}$$

where e_{ik} denotes the OLS residual from the equation estimating share i, and T the number of observations for share i.

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

$$Q=\sum_{t=1}^{T}\sum_{i=1}^{N}\sum_{j=1}^{N}\frac{(r_{it}-\lambda_{0t}-b_{i1}\lambda_1...b_{ik}\lambda_k)(r_{jt}-\lambda_{0t}-b_{j1}\lambda_1...b_{jk}\lambda_k)}{S_{ij}}$$

This entire procedure was performed using the ETS sub-module of the SAS computer software package.

The study tests the significance of the four macroeconomic factors tested by Chen et al. (1986) and the residual market risk factor. With 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. The five factors accounted for 24% of the returns on the individual shares and all 5 factors were priced.

3.4 Choice of method

There are several statistical problems inherent in the Chen et al (1986) approach which are not encountered with the approach of McElroy and Burmeister:

1. In the Chen et al model, estimates from stage one (the asset betas) are used as inputs in a 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. Because joint estimates of beta and the risk-premiums are produced in one step by the McElroy and Burmeister approach, this problem is obviated.

2. In the second stage of the method used by Chen et al., portfolios that diversify away the unsystematic risk in the returns need to be derived so as to control the errors-in-the-variables problem. The McElroy and Burmeister 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 model or their characteristics (eg. normality, 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 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 and Burmeister, 1988, 29).

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

3.5 Summary

A promising approach to identifying the APT factors involves pre-specifying a set of factors and determining how well they explain share returns. Its prime advantages are that it overcomes the problems of factor analysis and identifies the nature of the factors. This makes the theory more meaningful.

The first test of this approach was carried out by Chen, Roll and Ross (1986) and reported that four macroeconomic variables were important factors. Subsequent studies have suggested that another factor, a residual market risk factor, should be included so as to ensure that all systematic risk in the market factor is incorporated in the factors.

The four factors identified by Chen, Roll and Ross (1986) are unanticipated changes in: default premia, the term structure of interest rates, inflation and growth rates in industrial production. Although not part of the APT, there is a documented theoretical relationship between all of these factors and share returns.

When attempting to identify the APT factors by pre-specifying a factor set and testing it, there appears to be a choice of two methods. The so-called "two-step" method of Chen et al (1986) estimates the asset betas and the factor risk-premiums in two separate steps which introduces an errors-in-the-variables problem. The multivariate nonlinear regression model of McElroy and Burmeister (1988) is considered better for this test because the errors-in-the-variables problem is eliminated and the properties of the estimators are better known. In addition, it accommodates the inclusion of an unobservable residual market risk factor in the tests. The statistical method proposed by McElroy and Burmeister (1988) is thus adopted for this study. A more detailed analysis of this method is contained in Chapter 6.

CHAPTER 4: JUSTIFICATION FOR THE SELECTION OF FACTORS

4.1 Introduction

Being a very general theory, the APT specifies neither the number nor the nature of the factors. However, the McElroy and Burmeister (1988) testing method discussed in Chapter 3, which is to be used in this study, requires that factors be pre-specified before they can be tested. A researcher is thus faced with the task of identifying possible factors.

According to Sharpe (1984) there should not be too many factors for convenience and also to reduce collinearities amongst the factors. Page's South African study on the APT (1986) identified two factors but "the possibility of more 'priced' factors cannot be excluded with certainty" (Page, 1986, 42).

The factors to be tested are chosen from those suggested by economic theory and empirical studies of both the APT and related subjects.

The purpose of this chapter is to select the factors for testing and to substantiate this choice with corroborating evidence. In addition, the variable that will be used to measure the actual movement is stated for each factor. A factor should measure only the unexpected movement in the variable and so Chapter 5 discusses the method used to estimate the expected portion of the movement in the variables so that this can be removed from the actual movement.

The following factors have been chosen for testing:

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;
7. Residual market risk factor.

4.2 Foreign exchange rate risk

4.2.1 Economic rationale

Because exchange rate fluctuations cause changes in the cost of imports and the selling prices of exports, a deterioration in the rand/ US dollar exchange rate should cause the cost of imported products to increase whilst also increasing the revenue derived from exports. Unanticipated movements in exchange rates should therefore lead to unanticipated movements in share prices.

In particular, gold shares should be affected by exchange rate risks because gold mines sell all of their gold production to the South African Reserve Bank and the selling price is determined by the international gold price. In addition, they are reliant on imports of capital equipment, the costs of which fluctuate with exchange rates changes.

Industrial shares are also likely to be affected by exchange risk, with the sensitivity of individual shares determined by the extent of their foreign exchange dealings.

4.2.2 Empirical studies

No international studies appear to have tested foreign exchange risk as an APT factor. Two related South African studies provide some evidence, although their findings are not consistent.

Westwell (1987) tested foreign exchange risk and found that it appeared to be a priced factor. In particular he noted that coal shares as well as DeBeers and Remgro were most sensitive to foreign exchange risks and that these are "traditional rand hedges on the JSE" (Westwell, 1987, 102). The fact that some shares are considered exchange rate hedges, indicates that exchange rates are a plausible factor affecting share prices.

Westwell concluded that foreign exchange rates were possibly a factor although this could not be determined with certainty.

Barr (1990) included the commercial rand and financial rand exchange rates in his biplot covariance test of the APT and found that these two variables were not well correlated with the two APT factors he identified.

4.2.3 Conclusion and measurement

There appears to be some empirical support from South African studies for including unexpected movements in the rand/US dollar exchange rate as an APT factor, although this evidence is inconclusive. The economic arguments for including foreign exchange risk are strong, however, and so unexpected changes in exchange rates are included as a factor for testing. This factor is measured as the unexpected movement in the month-end US dollar/ SA Rand commercial exchange rate. Details of the calculation of the unexpected movements in the factors is given in 5.3.

4.3. Unexpected changes in default risk premiums

4.3.1 Economic rationale

Default premium is a premium in an investor's returns to compensate for the risk of default in the payment of interest and capital. Default premium risk is the risk that the premium will change and is highest when the economy is in a recession. It is expected that default premia should affect share prices since the investor expects to be compensated with a premium for undertaking default risk.

4.3.2 Empirical evidence

This factor was first tested by Chen et al (1986) and was measured by the difference in returns on separate portfolios of corporate and government (risk-free) bonds. Portfolios were used since the corporate bonds would include some company-specific risk which should be removed by diversification before testing.

Their results suggested that the default premium risk factor was significantly different from zero over the entire period under study.

Burmeister and Wall (1986) also included a default factor in their tests with the appropriate measurement being the same as that used by Chen et al (1986). Regardless of whether a constant risk-free rate was specified or whether it was estimated from the data, default premium risk was significantly different from zero.

McElroy and Burmeister (1988) tested for this factor by using a slightly modified measurement given by:

$$DPR(t) = GB(t) - CB(t) + C$$

where: DPR(t) = the unexpected change in the default premium at time t;
GB(t) = return on a portfolio of long-term government bonds at time t;
CB(t) = return on a portfolio of long-term corporate bonds at time t;
C = the difference in expected returns on GB(t) and CB(t).

The two portfolios should contain bonds of equal maturities, so that the effects of the term structure of interest rates are not included in the default factor.

The default risk premium was a statistically significant factor in the McElroy and Burmeister study.

4.3.3 Conclusion and measurement

As both economic theory and empirical studies support the default premium risk as an important factor, it is considered worthy of inclusion. The measure of default risk is not the usual one tested by Chen et al (1986) and McElroy and Burmeister (1988) because the JSE has only 4 company debentures which are listed and this would clearly be too few to eliminate company-specific risks. This measure was thus impractical and a proxy was used for default premium risk, namely, the unexpected movement in the number of companies liquidated. Details of the calculation of the unexpected movements in the factors is given in 5.3.

4.4 Inflation risk factor

4.4.1 Economic rationale

Two different schools of thought of the effects of inflation on share returns can be distinguished. The oldest theory is known as the Fisher effect and posits that increases in inflation raise the investor's required rate of return by an equal amount, thus causing a positive relation between the two variables. However, Bodie (1976), Jaffe and Mandelker (1976) and Nelson (1976) have all documented a negative correlation between share returns and inflation. Reasons to explain this phenomenon have differed from investor irrationality (Modigliani and Cohn, 1979) to tax effects caused by historical depreciation (Lintner, 1975).

More recently, Fama (1981) and Geske and Roll (1983) have suggested that although there is a correlation between share prices and inflation, there is, in fact, no causation. Other variables, such as real activity, affect both share prices and inflation. Thus, there appears to be a link between the two but they are not directly related; only indirectly through real activity. The debate remains unresolved.

4.4.2 Empirical evidence

4.4.2.1 Correia and Wormald (1988)

In a South African study on the association between stock market returns and rates of inflation, Correia and Wormald (1988) reported that there was a zero correlation between expected inflation and share returns. There was a negative and statistically significant relationship between changes in short term interest rates (a proxy for expected inflation) and share returns. This evidence suggests that "one must question the widely held view that share returns are directly related to inflation with high rates of inflation supporting high stock market prices" (Correia and Wormald, 1988, 18). The outcome of this study is consistent with the APT model since only unexpected changes in inflation should be a factor.

4.4.2.2 Chen, Roll and Ross (1986)

This study included inflation risk as one of the pre-specified factors to be tested. 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 over the period 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 and these results are thus economically feasible. In addition, the signs of the coefficients were mostly negative which implied to the authors that stocks did perform as inflation hedges.

4.4.2.3 McElroy and Burmeister (1988)

This study attempted to employ a more accurate measurement of inflation rate risk. Again, unexpected inflation was taken as the difference between actual and expected inflation, except that expected inflation was measured by Kalman filtering techniques. The inflation factor was significantly different from zero but the least significant of the five factors tested since it had a p-value of 0.07 which was considerably higher than the other factors and indicates a lower level of significance.

4.4.3 Conclusion and measurement

The evidence supporting the inflation rate factor is inconclusive. The two APT studies discussed above both indicate that the risk factors were priced. Inflation rate risk may be a particularly volatile factor, the significance of which may change frequently as shown by Chen et al (1986), so causing the inconclusive results. However, there appears to be ample theoretical support for a relationship and inflation rate risk is thus included as a factor for testing. This study measures inflation risk as the unexpected movement in the % change in the Consumer Price

Index for all items. The calculation of the unexpected movement in the risk factor is described in 5.3.

4.5 Gold price risk

Unexpected changes in the gold price should affect both mining and industrial shares on the JSE. Gold price risk has not previously been tested as a factor in the APT because it is likely to be unique to South Africa.

4.5.1 Economic rationale

Historically, the mining industry led to rapid development of the South African industrial sector and continues to have a significant impact on it. Apart from the obvious impact of the higher gold price increasing the revenues of the mines (all gold produced must be sold to the SA Reserve Bank at a pre-determined price based on recent gold prices), 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 also be used in the industrial sector and it 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 and hence greater income.

4.5.2 Empirical evidence

The extent of the impact of the gold mining industry on the economy would appear to be peculiar to South Africa and there are thus no overseas APT studies which have incorporated a gold price factor. Several South African tests have examined the effect of the gold price on share prices - some under the APT framework and others not. Barr (1990) tested the APT in South Africa using a covariance biplot method. Gold shares were not included in the study "as their movement would quite clearly be dominated by movements in the gold price" (Barr, 1990, 17). However, the gold price still seemed to affect the industrial shares in his study. One of the factors he identified (the so-called industrial factor) was closely correlated with world metal prices and especially the gold price. Barr concludes that "this points to the fact 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 the various filter-through effects on the rest of the economy" (Barr, 1990, 21).

In an initial test of the APT in South Africa, Page (1986) found that one of the two factors identified was closely related to the mining sector. He used factor rotation to get certain of the shares to load heavily on each of the two factors and this resulted in "one of the rotated factors being composed exclusively of mining related shares whereas the other was a composite of mainly the industrial shares for all the groups" (Page, 1985, 42). This would suggest that the gold price could be a priced factor on the JSE.

4.5.3 Conclusion and measurement

Due to the unique nature of the South African economy and its reliance on the gold mining industry, gold price risk is expected to be a priced factor. It is supported by sound theoretical reasons and adequate empirical support. This study measures the gold price risk as the unexpected movement in the London gold price in dollars. The rand gold price was not used because the unexpected movements in the rand/US dollar exchange rate are separately specified as a factor. The calculation of the unexpected movement in the risk factor is described in 5.3.

4.6 Unanticipated movements in the term structure of interest rates

4.6.1 Economic rationale

The term structure of interest rates refers to the difference between long- and short-term rates of equal risk. A logical measure for interest rate risk is the difference between long- and short-term interest rates on government bonds (which can be assumed to be riskless). Thus, any effects of default premia should be excluded, which is desirable since these will be measured and separately tested as a default premium risk factor.

4.6.2 Empirical studies

There is considerable evidence from both local and overseas studies to indicate that interest rate risk is an important factor.

4.6.2.1 Chen, Roll and Ross (1986)

The authors were the first to test unanticipated movements in the term structure of interest rates. and reported that the factor had a t-value of -0.149 and the sign of the coefficient was negative.

The low significance of the factor is surprising. Chen et al (1986) also note that there was a strong correlation between the interest rate factor and the default premium factor, presumably since the measurements for both factors include the long-term rate of return on government bonds. This collinearity could have weakened the impact of the interest rate factor on share prices.

4.6.2.2 McElroy and Burmeister (1988)

Interest rate risk was also tested by McElroy et al. In contrast to the Chen et al study (1986), interest rate risk was the most significant factor over the test period with a reported t-statistic value of 4.76. Thus conflicting evidence on the importance of this factor is obtained.

4.6.2.3 Barr (1990)

Using a covariance-biplot method, Barr forces a two-factor structure on the data and concludes that gold and short-term interest rates are "two economic forces that are driving these factors" (Barr, 1990, 25) and particularly the first factor.

4.6.3 Conclusion and measurement

There is strong economic and theoretical evidence to support interest rate risk as a priced APT factor. Empirical evidence has been mixed but the McElroy and Burmeister (1988) study, whose method will be used, indicated a very significant relationship. It is thus considered to be suitable for inclusion in the set of factors to be tested. This study measures the term structure of interest rates risk as the unexpected movement in the difference between long-term and short-term interest rates. Long-term interest rates were measured by the RSA long-dated stock trading rate and short-term rates were measured by the 91 day Treasury Bill Rate. The calculation of the unexpected movement in the risk factor is described in 5.3.

4.7 The effect of unexpected changes in industrial production on share prices (growth rate risk)

4.7.1 Economic rationale

Fama (1981) provides both theoretical and empirical support for a positive relation between real activity and real stock returns. This is consistent with the rational expectations view that real economic variables should affect share prices. Measures of real economic activity include "capital expenditure, the average real rate of return on capital and output which we hypothesize reflect the variation in the quantity of capital investment with expected rates of return in excess of costs of capital" (Fama, 1981, 563).

4.7.2 <u>Empirical evidence</u>

Chen et al (1986) examined two measures of growth in industrial production: one monthly and one yearly. These were included so that both short- and long-term measures could be tested. They were measured as:

$$MP(t) = \log_e IP(t) - \log_e IP(t-1)$$

$$YP(t) = \log_e IP(t) - \log_e IP(t-12)$$

where: $MP(t)$ = growth rate factor measured monthly;
$YP(t)$ = growth rate factor measured yearly;
$IP(t)$ = the industrial production index (real final sales).

Their results indicated that the monthly growth factor was significantly different from zero over the entire period, whereas the yearly measure was not significant in any period. This is expected, since share prices were measured at monthly intervals.

McElroy and Burmeister (1988) used a similar measure but generated a real final sales series (excluding services) based on monthly and quarterly information in the GNP accounts. The measure is:

$$UGS_t = E_t[G_t] - E_{t+1}[G_t]$$

where: UGS_t = unexpected growth in real sales;
$E_t[G_t]$ = expectation at time t of actual real growth in sales;
$E_{t+1}[G_t]$ = expectation at time t+1 of actual real growth in sales at time t.

Expectations for G_t were generated by assuming that agents form their expectations from an autoregressive model involving lagged values of G_t and lagged values of real disposable income. Their results indicate that the growth risk is significantly different from zero.

4.7.3 Conclusion and measurement

The empirical and theoretical evidence appears to be sufficiently strong to include the growth rate factor in the tests. Furthermore, it is intuitively appealing that a factor as fundamental to the economy as the growth rate in industrial production should be a priced factor. This study measures the growth rate risk as unexpected movements in the quarterly % change in real Gross Domestic Product (the seasonally-adjusted rate). The calculation of the unexpected movement in the risk factor is described in 5.3.

4.8 The Residual Market Risk factor

Apart from the pre-specified observable factors, an unobservable factor is also proposed. This is commonly termed the residual market risk factor. Because there is no one "true" factor structure under the APT, the residual market factor is included in testing to ensure that the effects of all systematic risks in the market are measured.

4.8.1 A model with unobserved market factors

An unobserved market factor can be interpreted as a shock that is common to all asset returns at a given time, t, and as such can be distinguished from asset-specific risk.

McElroy and Burmeister (1988, 33) suggest that market psychology, confidence or sentiment and rumours of war or political risk could serve as valid unobserved market factors. To be valid, the unobserved factor must have the same characteristics as the observed factors. That is, it should have a zero mean, a constant variance and should be serially uncorrelated. It should also be uncorrelated with the unsystematic risk term, ϵ_{it}.

The returns on a market proxy portfolio $(w_1, \ldots w_N)$ are given by:

$$r_{mt}=\lambda_{0t}+\sum_{j=1}^{J} b_{mj}\lambda_j+b_{mK}\lambda_K+\sum_{j=1}^{J} b_{mj}f_{jt}+b_{mK}f_{Kt}+\epsilon_{mt} \qquad (4.1)$$

where:

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

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

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

Assuming that f_{Kt} can be normalized, 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:

$$r_{mt}=\lambda_{0t}+\sum_{j=1}^{J} b_{mj}\lambda_j+\lambda_K+\sum_{j=1}^{J} b_{mj}f_{jt}+f_{Kt} \tag{4.2}$$

Furthermore, λ_m can be defined as:

$$\lambda_m=\sum_{j=1}^{J} b_{mj}\lambda_j+\lambda_K \tag{4.3}$$

so that the equation can be reduced to:

$$r_{mt}=\lambda_{0t}+\lambda_m+\sum_{j=1}^{J} b_{mj}f_{jt}+f_{Kt} \tag{4.4}$$

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_{0t} and f_{jt} are measured and input into the model and λ_m, b_{mj} are to be estimated using ordinary least squares regression techniques.

An estimate for f_{Kt} can then be given by 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.

4.8.2 Economic rationale

This factor can be defined as the unanticipated change in the market index not explained by the other macro-economic factors tested. The measurement of the residual market factor can be based on the return on a particular stock market index such as the JSE Actuaries All Share Index. Only that portion of the return not explained by the other separately specified factors is considered to constitute a factor.

4.8.3 Empirical evidence

This factor was first introduced by Burmeister and Wall (1986), who tested the effect of the residual market risk on the explanatory power of the factors. The coefficient of determination increased significantly with the introduction of the fifth factor. In fact, it "is required to obtain a statistically significant estimate of the total risk premium for a portfolio" (Burmeister and Wall, 1986, 10). The results show that the adjusted-R^2 increases from 0.30 to 0.82 with the introduction of the residual market risk factor.

McElroy and Burmeister (1988) also examine the residual market factor reporting that the factor was significantly different from zero at the 1% level (probability value of 0.002) and was the third most important factor after the term structure of interest rates and the default premium factors.

4.8.4 Conclusion and measurement

Whilst the factor is unobservable, it can be estimated by f_k and so is included for testing. It is unlikely that the "best" factor structure will be selected by a priori research. The residual market factor ensures that any priced factors not explicitly specified for testing are nonetheless included in the study. Empirical evidence supports the testing of this factor.

This study measures the residual market risk from the equation (4.4) above with the return on the market portfolio being estimated by the JSE Actuaries All Share Index.

4.9 Conclusion

There is no unique and absolutely optimal set of APT factors. Neither are the factors for one market necessarily the same for another market. Even in a particular market, the risk factors can change over time. What is of utmost importance is that the factors reflect those systematic risks for which investors require compensation.

Seven possible factors have been selected for testing on the JSE. It is not imperative, and also unlikely, that all of these will be priced. Collinearities between the factors could affect the number of significant factors and prior South African research on the APT suggests a smaller number of priced factors. Nonetheless, the factors selected have sound economic links to share prices and are thus included in the test.

CHAPTER 5: DATA SELECTION

5.1 Introduction

This chapter addresses the question of data requirements and data selection. The factors to be used and their measurements are also noted. In addition, the problem of thin trading on the JSE and how it is dealt with in this study, is discussed. The sample's market capitalisation is analysed and compared to the total market capitalisation on an industry and sector basis. Furthermore, the mining and industrial sectors on the JSE appear to be affected by different factors. As a result, they are tested separately in this study. The rationale for this separation is also discussed.

5.2 Data sources

The share price data and the economic variable data were obtained from two separate data sources. Share prices were obtained from the University of Cape Town share price database, maintained at the Department of Statistics. The database appears to be "clean" in that it is updated for share splits and consolidations on a regular basis.

Economic variables were extracted from the Standard Bank Ecocats online system which was accessed at the Cape Town Graduate School of Business. The period under study was the 10 years from the 1 January 1980 to 31 December 1989. The returns were calculated on a monthly basis.

5.3 Factor measurements

Actual movements in the values of the variables used to measure the factors include both the expected and the unexpected portions. The APT specifies that only the unexpected movement in the variable constitutes a risk factor and should thus be used in testing. McElroy and Burmeister (1988) have noted that the factor should be unexpected at the beginning of the period and should be uncorrelated over time. Some adjustment must therefore be made to separate the expected and unexpected movements so that the factor will be unexpected at the beginning of the period. Actual movements in the variables were calculated as follows:

$$A_t = V_t - V_{t-1}$$

for t=1 to 120,

where: A_t = actual movement in variable in time t;
V_t = value of variable at time t;
V_{t-1} = value of variable in time period t-1.

In order to identify the unexpected movement in the variable a moving average of the previous 12 months observations were taken as a measure of the expected value of the variable. This was then subtracted from the matching observation of the actual movement to obtain the unexpected movements in the factor which was used in the McElroy and Burmeister (1988) model.

Thus,

$$U(A_t)=A_t-M(A_t)$$

for t=1, ... 120

where:
$U(A_t)$ = the unexpected movement in A at time t;
$M(A_t)$ = a moving average of the previous 12 months observations of A.

Share price returns are estimated by:

$$R_t=\frac{P_t-P_{t-1}}{P_{t-1}}$$

where: R_t = share return for month t;
P_t = share price at end of month t;
P_{t-1} = share price at end of month t-1.

The correct measure of a share's return is the capital portion (as shown in the above equation) as well as the dividend received. However, the database did not contain dividend information and so this was omitted.

5.4 Basis of share selection

The following requirements served as guidelines in determining which shares should be included in the study:

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 US 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 (for example, 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 so would 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 Actuaries Index was used since its stated aim is to "reflect the performance of the South African ordinary share market as a whole, as well as that of individual sectors or groups of shares that are considered to be affected by similar broad economic developments" (The Actuarial Society of South Africa, 1989, 3).

The total number of shares included in the JSE-Actuaries Index as at 2 January 1990 was 151 covering all sectors of the JSE. However, not all of these shares could be used in the study because the index is updated annually by the Actuarial Society to remove shares that do not trade frequently or are "cash shells", and to include shares that have performed well. As a result, a number of shares in the index were excluded from the study because they were not listed for the entire period under study. After these shares had been eliminated, there were 80 shares remaining which could be used in the study.

5.5 Frequency of trading

The JSE is notorious for the low volume of shares traded on the market - a phenomenon known as "thin trading". The JSE estimates that annual turnover amounts to only 6% of total market capitalisation. This is clearly low when compared to turnover percentages of 65% for the NYSE, 60% for the AMEX, and 24% for the LSE, (The JSE Centenary Publication, 1987, 134). Robin McGregor has estimated that "only 10%-15% of shares registered on the JSE are actually traded" (The JSE Centenary Publication, 1987, 134). 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. Various reasons have been cited for thin trading. A possible cause is structural in nature. It is due to "a meaningful part of total capitalisation being locked up in pyramids, intermediate holding companies and in cross holdings, which rarely, if ever trade" (JSE Centenary publication, 1987, 44). Whilst this appears to be the major contributor, other factors such as the existence of a marketable securities tax and normal tax on certain capital profits also result in a reduction in turnover of shares.

Whatever its cause, 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. There have been several South African studies on the liquidity of the JSE, including Barr and Bradfield (1988). They report that thin-trading has an impact on both share prices and the market indices.

In an attempt to overcome this problem, the weekly trading volumes of the 80 selected shares were examined. If a share failed to trade in 20 weeks out of the 10 years (2 weeks per year), then the share was excluded from the sample. 27 shares or 33.75% of the initial sample were eliminated in this way due to infrequent trading. A similar approach has 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 side-step the problem by choosing shares that are known to be well traded. Hence some of the problems of thin trading should be obviated.

The remaining sample from the JSE Actuaries Index thus consisted of 53 shares which was considered to be insufficient and contained inadequate coverage in several sectors. In particular, no shares from the banks and financial services sector were included because many of the shares were banks which were only listed in 1987 after a change in legislation, allowing banks to be public companies. Thus, a further sample of shares was chosen from the various sectors of the JSE. An additional 19 shares were chosen that met the criteria of being listed for the entire period under study and trading for a minimum of 500 weeks in the 520 weeks. The additional shares included bank shares and provided adequate coverage. These shares were also a set of smaller companies and so the final sample is a set of 72 well-traded shares.

5.6 Market coverage

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.

An analysis of the sectors covered by the sample indicates the following, with market capitalization calculated on 2 January 1990:

Sector and shares chosen	**Number of shares**	**% Market Cap. tested per sector**
<u>Mining</u>		
Coal	2	75.68
amcoal		
trans-natal		
Diamonds	1	98.33
deBeers		
Gold - Rand and others	3	67.15
ergo		
et-cons		
randfontein		
Gold - Evander	1	46.36
kinross		
Gold - Klerksdorp	2	48.88
harties		
southvaal		
Gold - OFS	0	0.00
Gold - West Wits	2	57.93
dries		
kloof		
Copper	1	100.00
palamin		
Manganese	1	72.31
samancor		
Platinum	2	81.72
implats		
rusplats		
Tin	0	0.00
Other metals & minerals	0	0.00
<u>Mining Financial</u>		
Mining Houses	3	79.96
anglos		
gencor		
goldfields SA		
Mining Holding	2	50.73
genbel		
minorco		

Sector and shares chosen	**Number of shares**	**% Market Cap. tested per sector**
<u>Financial</u>		
Banks & Financial Services	4	50.61
bankorp		
boland		
nedcor		
sbic		
Insurance	2	45.47
liberty		
santam		
Investment Trusts	0	0.00
Property	2	19.17
amaprop		
gf-props		
Property Trusts	4	24.24
pioneer		
sanland		
prima		
fedfund		
<u>Industrial</u>		
Industrial Holdings	5	48.57
AMIC		
AVI		
barlows		
malbak		
btr-dunlop		
Beverages & Hotels	1	66.42
sabrews		
Building & Construction	7	61.49
concor		
ang-alpha		
LTA		
Otis		
PPC		
goldstein		
blue-circle		
Chemicals	3	93.38
AECI		
sasol		
sentrachem		
Clothing, Footwear & Textiles	2	13.16
romatex		
seardel		
Electronics, Electrical & Battery	1	5.49
powertech		

Sector and shares chosen	**Number of shares**	**% Market Cap. tested per sector**
Engineering	4	38.98
abercom		
afrox		
dorbyl		
metkor		
Food	6	80.15
fedfood		
premier		
ICS		
I&J		
tiger-oats		
kanhym		
Furniture & Household Goods	1	29.49
afcol		
Motors	1	18.91
mccarthy		
Paper & Packaging	2	74.58
nampak		
sappi		
Pharmaceutical & Medical	0	0.00
Printing & Publishing	0	0.00
Steel & Allied	1	15.38
hiveld		
Stores	4	27.41
clicks		
ok		
pepkor		
picknpay		
Sugar	1	90.36
tongaat		
Tobacco & Match	1	96.93
rembrandt		
Transportation	0	0.00

[Source of information: The JSE Actuaries Index 1989 and The JSE Handbook, August 1991]

The above table indicates that there was an adequate spread across each of the market sectors. The overall coverage in the 3 main sectors is:

Sector	% market capitalization
Mining	66.52
Financial	37.19
Industrial	54.46
Total	60.14

5.7 Market separation

"The underlying macro-economic variables determining the return generating process can be divided into those that influence the mining sector to a greater extent and those that effect the industrial sector to a greater extent" (Page, 1986, 42). This concluding remark to Page's South African APT study reports a result apparent in many empirical studies on the JSE - that the mining and the industrial sectors can almost be considered to be two separate markets.

Separate testing of the two sectors should improve the accuracy of tests because a factor may not be significantly different from zero in one sector but strongly significant in the other. Tested together they could probably produce an insignificant result.

The following reasons indicate the separation of the mining and industrial sectors. The mining origins of the JSE are still apparent in the present nature of the market. As at the 30 June 1987, mining shares comprised almost 60% of the market capitalisation of the JSE (The JSE Centenary Publication, 1987, 44) and gold shares accounted for 38% of total market value (The JSE Centenary Publication, 1987, 23). This clearly indicates the significance of mining to the JSE.

In addition to the size of the mining sector, the nature of mining activities are very different to industrial operations. Hence, the risks that affect one sector may not affect the other. The differences between the mining and industrial sectors is also highlighted by the higher degree of foreign ownership in the mining sector. Although this has diminished due to political disinvestment, it has been estimated that foreign ownership of gold mining shares in 1979 was about 43% but which was reduced to 28% in May 1986 (The JSE Centenary Publication, 1987).

Furthermore, the liquidity of the mining sector is considered to be greater than that of the industrial sector (Barr and Bradfield, 1988, 288). These four differences support the contention that the JSE is divided into two distinct parts.

This has been borne out in several studies on the JSE. The concept of market separation was initially proposed by Gilbertson and Goldberg (1981). Page (1986) reported that a process of factor rotation led to one of the 'rotated' factors being composed exclusively of mining related shares whereas the other was a composite of mainly industrial shares for all groups" (Page, 1986, 42). This would indicate that the factor structure of the JSE could be separated between the mining and the industrial sectors. This separation has also been used by

Page (1989) and Barr (1990) in testing the APT in South Africa.

In conclusion, the separation of testing in the mining and industrial (including the financial) sectors seems to be a logical step. Due to several differences between the sectors, the identification of an APT factor structure should be improved by testing the sectors separately. If the factors affecting the mining and industrial sectors are different then a more accurate assessment of the factor structures can be made with separate testing.

5.8 Summary

Share returns were measured on a monthly basis between 1 January 1980 and 31 December 1989. A sample of 72 shares were chosen: 20 from the mining and mining financial sectors, 12 from the financial sector and 40 from the industrial sector. The shares selected were all well-traded in the period of the study since they traded for a minimum of 500 out of the 520 weeks. Due to the different natures of the mining and industrial sectors, they can be considered to be separate markets. As a result, the mining and industrial sectors will be tested separately in this study.

CHAPTER 6: TESTING METHODS

6.1 Introduction

This chapter reviews the statistical methods used in this study. In chapter 3, the testing methods of Chen et al (1986) and McElroy and Burmeister (1988) were examined and compared. The multivariate nonlinear regression model of McElroy and Burmeister was considered better for this test because the errors-in-the-variables problem is eliminated and the properties of the estimators are better known. This method thus used to test the model under constraints which reflect the APT assumptions and is referred to as the "APT model". Another series of tests, uses a seemingly unrelated regression (SUR) model without the constraints that reflect the assumptions of the APT. This model can be useful for comparisons to determine whether the predictive power (as measured by the adjusted-R^2 values) of the APT model is at least as good as that of the model without the APT constraints. A similar comparison was also performed by McElroy and Burmeister (1988). The seemingly unrelated regression model is preferred to an ordinary least squares regression model in this study, since the assumptions relating to the error terms are the same as those used in the APT model, namely that the residuals are mutually correlated between shares but uncorrelated over time, or

$$E(e_i e_j') = \sigma_{ij} I_T \qquad (6.1)$$

for share i and j and time periods t=1, ... T

By contrast, the ordinary least squares regression procedure assumes that the covariance between residuals is zero.

A description of the APT model of McElroy and Burmeister (1988) and the seemingly unrelated regression models is discussed below.

6.2 <u>The APT model of McElroy and Burmeister (1988)</u>

The APT model can be written as a system of n nonlinear regressions over T periods of the form:

$$R_{it}-R_{ft}=\sum_{j=1}^{K} b_{ij}\lambda_j+\sum_{j=1}^{K} b_{ij}f_{jt}+\epsilon_{it} \tag{6.2}$$

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

where:
R_{it} = the rate of return on share i for time t;
R_{ft} = the risk-free rate of return for time t;
b_{ij} = the sensitivity of share i to the factor j;
λ_j = the risk-premium of share j;
f_{jt} = the unexpected movement in factor j at time t;
ϵ_{it} = the error term for share i in period t.

This can be rewritten as:

$$\boldsymbol{\rho}_i=\sum_{j=1}^{K}(\lambda_j\boldsymbol{\iota}_T+\boldsymbol{f}_j)\,b_{ij}+\boldsymbol{\epsilon}_i \tag{6.3}$$

where:
$\boldsymbol{\rho}_i = (r_{i1}-r_{f1}, \ldots\ldots r_{iT}-r_{fT})'$ for i = 1, ... n
$\mathbf{f}_j = (f_{j1}, \ldots\ldots f_{jT})'$ for j = 1, ... k
$\boldsymbol{\epsilon}_i = (\epsilon_{i1}, \ldots\ldots \epsilon_{iT})'$ for i = 1, ... n
and ι_T is a T-dimensional vector of 1' s.

The above system can be written in matrix form as:

$$\boldsymbol{\rho}_i=\boldsymbol{X}(\lambda)\,\boldsymbol{b}_i+\boldsymbol{\epsilon}_i \tag{6.4}$$

where:

$\mathbf{X}(\boldsymbol{\lambda}) = (\boldsymbol{\lambda}' \otimes \iota_T) + \mathbf{F}$
$\lambda = (\lambda_1, \ldots\ldots, \lambda_k)'$
$\mathbf{F} = (\mathbf{f}_1, \ldots\ldots, \mathbf{f}_k)'$
$\mathbf{b}_i = (b_{i1}, \ldots\ldots, b_{ik})'$ for i = 1,....,n
and $\otimes$ denotes the Kronecker product

Stacking the n equations yields

$$\begin{bmatrix} \rho_1 \\ \rho_2 \\ \cdot \\ \rho_n \end{bmatrix} = \begin{bmatrix} X(\lambda) & 0 & \cdots & 0 \\ 0 & X(\lambda) & \cdots & 0 \\ \cdot & \cdot & \cdots & \cdot \\ 0 & 0 & \cdots & X(\lambda) \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \\ \cdot \\ b_n \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \cdot \\ \epsilon_n \end{bmatrix}$$

which can also be stated as:

$$\rho = [I_n \otimes X(\lambda)]\, b + \epsilon \qquad (6.5)$$

where:

$\rho = (\rho_1,\ \rho_2,\ \ldots\ \rho_n)'$
$b = (b_1,\ b_2,\ \ldots\ b_n)'$
$\epsilon = (\epsilon_1,\ \epsilon_2,\ \ldots\ \epsilon_n)'$

and $E\{\epsilon\} = 0_{nT}$ and $E\{\epsilon\epsilon'\} = [\Sigma \otimes I_T]$

A nonlinear seemingly unrelated regression estimation technique can be used to obtain estimates in three steps.

Step 1: The ordinary least squares regression procedure is performed on a share-by-share basis on the following equation

$$\rho_i = \sum_{j=1}^{K} (\lambda_j \iota_T + f_j)\, b_{ij} + \epsilon_i \qquad (6.6)$$

to obtain estimates for $(\hat{b}_{ij})_{j=1}^{K}$

and the crossproduct sum

$$b_{io} = \sum_{j=1}^{K} \lambda_j b_{ij}$$

This is the same procedure as followed in the first step of the Fama-MacBeth two step procedure

These estimates are then plugged into the regression to obtain the associated residuals,

$$\hat{\boldsymbol{\varepsilon}}_i=\boldsymbol{\rho}_i-\sum_{j=1}^{K}\hat{b}_{io}\boldsymbol{\iota}_T+\boldsymbol{f}_j\hat{b}_{ij} \tag{6.7}$$

Step 2: The residuals obtained from step 1 are used to estimate the (i,j)'th elements of Σ, as follows:

$$\hat{\sigma}_{ij}=T^{-1}\hat{\varepsilon}_i'\hat{\varepsilon}_j \tag{6.8}$$

Step 3: Once Σ has been estimated it can then be substituted back into the following quadratic form, Q:

$$Q=[\boldsymbol{\rho}-(\boldsymbol{I}_n\otimes\boldsymbol{X}(\lambda))\boldsymbol{b}]'(\hat{\Sigma}^{-1}\otimes\boldsymbol{I}_T)[\boldsymbol{\rho}-(\boldsymbol{I}_n\otimes\boldsymbol{X}(\lambda))\boldsymbol{b}] \tag{6.9}$$

which can then be minimized with respect to λ and b to yield an estimate for b and λ.

6.3 <u>The seemingly unrelated regression model</u>

The model for an individual share i can be given by:

$$(R_{it}-R_{ft})=\beta_{io}+\sum_{j=1}^{K}\beta_{ij}f_{jt}+e_{it} \tag{6.10}$$

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

where: R_{it} = return on share i at time t;
R_{ft} = the risk-free rate of return at time t;
β_{i0} = an intercept term;
β_{ij} = the sensitivity of share i to factor j;
f_{jt} = the unexpected movement in factor j at time t;
e_{it} = the error term for share i at time t.

and $E(e_ie_j') = \sigma_{ij}I_T$.

Using vector notation, let
$\mathbf{Y}_i = (r_{i1} - r_{f1}, \ldots, r_{iT} - r_{fT})'$
$\boldsymbol{\beta}_i = (\beta_{i0}, \beta_{i1}, \ldots, \beta_{ik})'$

$$X_1 = \begin{bmatrix} 1 & f_{11} & \dots & f_{k1} \\ . & . & \dots & . \\ 1 & f_{1T} & \dots & f_{kT} \end{bmatrix}$$

$\mathbf{e}_i = (e_{i1}, \dots\dots, e_{iT})'$

Thus, equation 6.10 above can be restated as:

$$\mathbf{Y}_i = \mathbf{X}_i\beta_i + \mathbf{e}_i \qquad (6.11)$$

for i=1 to n.

Grouping these n model structures into a single structure:

$$\begin{bmatrix} Y_1 \\ Y_2 \\ . \\ Y_n \end{bmatrix} = \begin{bmatrix} X_1 & 0 & \dots & 0 \\ 0 & X_2 & \dots & 0 \\ . & . & \dots & . \\ 0 & 0 & \dots & X_n \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ . \\ \beta_n \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \\ . \\ e_n \end{bmatrix}$$

$$\mathbf{Y}^* = \mathbf{X}^* \beta^* + \mathbf{e}^*$$

one obtains a seemingly unrelated regression model structure where the error structure $\mathbf{e}^*$, has the form:

$$\begin{bmatrix} e_1 \\ . \\ e_n \end{bmatrix} \sim \left[\begin{bmatrix} 0 \\ . \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_{11}I_T & \sigma_{12}I_T & \dots & \sigma_{1n}I_T \\ . & . & \dots & . \\ \sigma_{n1}I_T & \sigma_{n2}I_T & \dots & \sigma_{nn}I_T \end{bmatrix} = \begin{bmatrix} \sigma_{11} & \dots & \sigma_{1n} \\ . & \dots & . \\ \sigma_{n1} & \dots & \sigma nn \end{bmatrix} \otimes I_T = \Sigma \otimes I_T \right]$$

Zellner's seemingly unrelated estimation technique can then be used to estimate the model parameters as follows:

Step 1: Ordinary least squares regression estimation is used on each of the individual share regression models, given by:

$$\mathbf{Y}_i = \mathbf{X}_i\beta_i + \mathbf{e}_i \qquad (6.12)$$

for i = 1 to n

These regression procedures yield estimates of the residuals, $\hat{e}_i$.

Step 2: The residuals are then used to estimate the (i,j)'th elements of the Σ matrix, namely σ_{ij}

$$\hat{\sigma}_{ij} = \hat{e}_i'\hat{e}_j/n = (Y_i - X_i\hat{\beta}_i)'(Y_j - X_j\hat{\beta}_j)/n \qquad (6.13)$$

where

$$\hat{\beta}_i = (X_i'X_i)^{-1}X_iY_i \qquad (6.14)$$

These estimates can then be substituted into Σ to yield the following feasible generalised least squares estimator for β^*, namely

$$\beta^*(\hat{\Sigma}) = (X^{*\prime}(\hat{\Sigma}^{-1}\otimes I)X^*)^{-1}X^{*\prime}(\hat{\Sigma}^{-1}\otimes I)Y^* \qquad (6.15)$$

where:

$$\hat{\Sigma} = \begin{bmatrix} \hat{\sigma}_{11} & \cdots\cdots & \hat{\sigma}_{1n} \\ . & \cdots\cdots & . \\ \hat{\sigma}_{n1} & \cdots\cdots & \hat{\sigma}_{nn} \end{bmatrix} \qquad (6.16)$$

CHAPTER 7: TEST RESULTS

7.1 Criteria for selecting a model

Results for mining and industrial shares have been generated by regressing separately their share returns against all combinations of factors.

What remains is to select appropriate models which are able to explain a significant percentage of the variability in share returns. The model chosen should explain not necessarily the highest but a satisfactorily high percentage of the variation in share returns. A percentage of the total variation in the return on each share which is explained by the regression model is given by the multiple coefficient of determination, R^2. Gujarati (1988) warns that in models with more than one explanatory variable, the R^2 values can be a misleading statistic because every additional variable will increase the amount of variation explained by the model, even if marginally so. Thus, as the number of variables rises, the R^2 (or ratio of explained variation to total variation) will tend to increase, even though the new variables may add very little explanatory power to the model.

This study uses the adjusted-R^2 which solves this problem by adjusting the R^2 for the degrees of freedom (or number of sample items less the number of explanatory variables). It can be shown that the adjusted-R^2 can decrease as variables are added, and so is more useful as it gives a truer reflection of the explanatory power of the model.

The model to be chosen should have significant t-statistics for the lambdas (indicating that the factors are priced factors), as well as a high adjusted-R^2 value. The significance of the risk-premiums and the beta coefficients will be determined by using the t-test. However, cognisance must also be taken of the economic knowledge of the parameters. Gujarati (1988, 186) warns against "playing the game of maximizing R^2", that is, choosing the model that gives the highest R^2. The danger lies in choosing a regression model that has a high R^2 value but regression coefficients that are either statistically insignificant or with signs which are contrary to a priori expectations.

7.2 Results of APT tests on Mining shares

7.2.1 One-factor models

Each of the factors selected in Chapter 4 was tested against the mining share returns by performing the regression procedures described as the McElroy and Burmeister APT model in 6.2. This yields estimates for b and λ of the form:

$$E(R_{it}) = R_{ft} + b_{ij}\,\lambda_j$$

for j=1,....6 and where:

$E(R_{it})$ = expected return on share i at time t;
R_{ft} = the risk-free rate of return during time t;
b_{ij} = the sensitivity of share i to the jth factor;
λ_j = the risk-premium of factor j.

The estimates of the factor risk-premiums (λ's) and their associated prob>|T| values are reported in Table 7.1 as well as the average adjusted-R^2 values which were calculated by taking a simple average of the adjusted-R^2 values for each share in the sample.

Table 7.1 SUMMARY OF APT RESULTS FOR ONE-FACTOR MODELS

Factor	Average adjusted-R^2	λ_j	prob>|T|
1 (foreign exchange risk)	0.0182	0.00932	0.2697
2 (default premium risk)	-0.001	-0.0779	0.2721
3 (inflation risk)	-0.005	-0.0828	0.4465
4 (gold price risk)	0.1444[3]	0.0174	0.0228
5 (term structure of interest rates risk)	0.0011	-0.0014	0.9957
6 (growth rate risk)	0.0154[4]	0.05564	0.0119

Factors 4 and 6 were chosen for further examination because they had high average adjusted-R^2 values. In addition, they both had low values for the prob>|T| statistic, indicating that their parameter coefficients were significantly different from zero at the 3% level of significance.

7.2.1.1 Results for gold price risk

Table 7.2 reports the beta estimates for each share, as well as the t-values and related prob>|T| statistics and the adjusted-R^2 value for each share for a model containing the gold price factor (factor 4).

[3] Per Table 7.2, the sum of the adjusted-R^2 values is (0.2054 + ...+ 0.1255) = 2.887. When averaged this equals 2.887/20 shares = 0.1444

[4] Per Appendix A, the sum of the adjusted-R^2 values is (0.0154 + ... + 0.0176) = 0.3088. The average is then 0.3088/20 shares = 0.0154

TABLE 7.2

MINING SHARES: APT RESULTS FOR GOLD PRICE RISK (FACTOR 4)

The equation is:

$$r_{it} = r_{ft} + b_{i4}\lambda_4 + b_{i4}f_{4t} + \epsilon_{it}$$

which resulted in the following estimate of expected return when the APT model was run:

$$E(r_{it}) = R_{ft} + b_{i4}\ 0.0174$$

share	b estimate	t-value	prob>|T|	Adjusted-R^2
kinross	0.981686	5.57	0.0001	0.2054
kloof	0.746253	5.55	0.0001	0.2009
minorco	0.496919	2.88	0.0047	0.0499
palamin	0.362685	3.22	0.0017	0.0824
randfontein	0.959286	6.42	0.0001	0.2592
rusplat	0.841721	5.57	0.0001	0.1927
southvaal	0.742190	5.08	0.0001	0.1717
amcoal	0.066141	0.50	0.6211	0.0023
samancor	0.339614	2.10	0.0375	0.0310
anglo	0.669074	5.69	0.0001	0.2061
implats	0.723118	4.32	0.0001	0.1203
trans-natal	0.202619	1.57	0.1200	0.0188
debeers	0.440677	3.40	0.0009	0.0806
driesfontein	0.588628	4.93	0.0001	0.1691
et-cons	0.870240	5.67	0.0001	0.1982
ergo	0.927941	5.63	0.0001	0.2123
harties	0.858253	6.11	0.0001	0.2350
genbel	0.655842	4.39	0.0001	0.1305
gencor	0.634689	5.44	0.0001	0.1951
goldfields SA	0.714025	4.30	0.0001	0.1255

The results in Table 7.2 indicate that all the share beta coefficients for the gold price risk are significant at the 1% level of confidence, apart from the coal mining shares (amcoal and trans-natal) and the manganese share (samancor). These shares also have very low adjusted-R^2 values compared to the other shares in the sample. The low explanatory power of the model for these particular shares is not surprising considering that the price of the commodities they mine are more likely to be significant determinants of their returns, although unrelated to the macroeconomic factors in the models. The adjusted-R^2 values of all of the gold mines and gold mining groups are much higher than non-gold mines.

7.2.1.2 Results for growth rate risk

Appendix A presents the results obtained for factor 6, namely, the growth rate risk. Based on the adjusted-R^2 values and the t-ratios of the model estimates for the individual shares, the gold price risk factor appears to be superior to the growth rate risk.

7.2.2 Two-factor models

The APT tests were then performed on models containing two factors, ie. using the APT model described in 6.2 to estimate b and λ, given by:

$$E(R_{it}) = R_{ft} + b_{ij}\,\lambda_j + b_{ik}\,\lambda_{ik}$$

for shares i=1,...N and factors j and k.

All sets of two factors were tested, including the residual market risk. The estimates of the factor risk-premiums (λ's) and their prob>|T| values (below in parenthesis) are reported in Table 7.3 as well as the average adjusted-R^2.

TABLE 7.3

SUMMARY OF APT RESULTS FOR TWO-FACTOR MODELS

Factors	Average adjusted-R^2	λ_j (prob>|T|)	λ_k (prob>|T|)
1 & 2	0.0171	0.00873 (0.3111)	-0.0719 (0.3164)
1 & 3	0.0136	0.01217 (0.1904)	-0.1596 (0.1979)
1 & 4	0.1429	0.00317 (0.7476)	0.017 (0.0447)
1 & 5	0.0191	0.01169 (0.2013)	-0.1252 (0.6638)
1 & 6	0.0305	0.00428 (0.6593)	0.05096 (0.0162)
1 & 7	0.4966	0.00436 (0.6189)	0.00892 (0.0036)
2 & 3	0.0051	-0.0748 (0.3003)	-0.0617 (0.5796)
2 & 4	0.1443	-0.0656 (0.3596)	0.01625 (0.0378)
2 & 5	0.0011	-0.0779 (0.2802)	0.0852 (0.7558)
2 & 6	0.0142	-0.0369 (0.6458)	0.04938 (0.0188)
2 & 7	0.4974	-0.0762 (0.289)	0.01046 (0.0001)
3 & 4	0.1427	-0.1938 (0.1416)	0.02293 (0.013)
3 & 5	0.002	-0.1078 (0.3408)	-0.0518 (0.8515)
3 & 6	0.0131	-0.1134 (0.3805)	0.0549 (0.0134)
3 & 7	0.4926	-0.1117 (0.4041)	0.01086 (0.0001)
4 & 5	0.14	0.0174 (0.0204)	0.14039 (0.6115)
4 & 6	0.1511	0.01324 (0.1292)	0.04738 (0.025)
4 & 7	0.4843	0.00839 (0.4041)	0.00921 (0.122)
5 & 6	0.0192	0.10068 (0.7432)	0.05247 (0.0141)
5 & 7	0.492	0.17362 (0.5277)	0.01036 (0.0001)
6 & 7	0.4903	0.02548 (0.2228)	0.00828 (0.109)

The models including the residual market risk factor (factor 7) have much higher average adjusted-R^2 values than the models which exclude factor 7. The differences in the average adjusted-R^2 values of the models including the residual market risk factor are very small and so no model was clearly superior in terms of adjusted-R^2 values. Because the model with factor 4 and the model with factor 6 had the highest average adjusted-R^2's of the one-factor models (noted in Table 7.1) and had risk-premium coefficients which were significantly different from zero, the models including each of these factors and the residual market risk factor are reported below.

7.2.2.1 Results for the model with gold price risk and residual market risk

The results for the model including the gold price risk (factor 4) and the residual market risk factor (factor 7) are presented in Table 7.4. The model with growth rate risk (factor 6) and the residual market risk factor (factor 7) is presented in Appendix B. The beta estimates together with the t-test values, prob>|T| values and the adjusted-R^2 value for each share are reported.

TABLE 7.4

MINING SHARES: APT RESULTS FOR GOLD PRICE AND RESIDUAL MARKET RISKS (FACTORS 4 AND 7)

The APT model equation estimated is

$$r_{it} = r_{ft} + b_{i4}\lambda_4 + b_{i4}f_{4t} + b_{i7}\lambda_7 + b_{i7}f_{7t} + \epsilon_{it}$$

which resulted in the following estimation of expected returns:

$$E(r_{it}) = R_{ft} + b_{i4}\ 0.00839 + b_{i7}\ 0.00921$$

share	b estimate	t-value	prob>|T|	Adjusted-R^2
kinross				0.6017
b4	0.972520	7.73	0.0001	
b7	1.521861	10.94	0.0001	
kloof				0.5422
b4	0.739387	7.21	0.0001	
b7	1.077457	9.50	0.0001	
minorco				0.3024
b4	0.473235	3.16	0.0020	
b7	1.103946	6.69	0.0001	
palamin				0.2957
b4	0.361991	3.63	0.0004	
b7	0.669110	6.08	0.0001	
randfontein				0.6022
b4	0.957978	8.70	0.0001	
b7	1.239750	10.17	0.0001	
rusplat				0.5671
b4	0.818528	7.34	0.0001	
b7	1.270966	10.31	0.0001	
southvaal				0.5091
b4	0.731179	6.45	0.0001	
b7	1.145179	9.14	0.0001	
amcoal				0.2048
b4	0.058275	0.48	0.6300	
b7	0.742647	5.57	0.0001	
samancor				0.1415
b4	0.324218	2.11	0.0370	
b7	0.692489	4.08	0.0001	
anglo				0.7673
b4	0.657220	10.24	0.0001	
b7	1.206061	16.96	0.0001	
implats				0.5331
b4	0.698496	5.67	0.0001	
b7	1.410743	10.36	0.0001	
trans-natal				0.1568
b4	0.214961	1.77	0.0792	
b7	0.599647	4.48	0.0001	

debeers				0.5867
b4	0.427537	4.86	0.0001	
b7	1.175839	12.08	0.0001	
dries				0.5194
b4	0.587718	6.42	0.0001	
b7	0.945309	9.35	0.0001	
et-cons				0.5205
b4	0.849604	7.11	0.0001	
b7	1.203759	9.11	0.0001	
ergo				0.4343
b4	0.936261	6.65	0.0001	
b7	1.068097	6.86	0.0001	
harties				0.6228
b4	0.853321	8.60	0.0001	
b7	1.219824	11.11	0.0001	
genbel				0.5532
b4	0.642157	5.94	0.0001	
b7	1.275630	10.68	0.0001	
gencor				0.6516
b4	0.629228	8.13	0.0001	
b7	1.071947	12.52	0.0001	
goldfields SA				0.5742
b4	0.697462	5.97	0.0001	
b7	1.454273	11.26	0.0001	

The adjusted-R^2 values of the non-gold mining shares are higher than the model including only gold price risk (Amcoal 0.2048, Samancor 0.1415, Trans-natal 0.1568). However, the largest increases in the average adjusted-R^2 values, are in the gold mining shares such as anglo (0.7673), randfontein (0.6022) and harties (0.6228). Per Table 7.3, there is, however, a probability of 40% that the price accorded by the market to the gold price factor is zero and a 12% probability that the price accorded to the residual market risk factor is zero.

7.2.2.2 <u>Results for growth rate risk and residual market risk</u>

Appendix B reports the results for the model including growth rate risk and residual market risk. The adjusted-R^2 values for the model with factors 6 and 7 is slightly higher at 0.4903 (compared to 0.4843 for factors 4 and 7).

Per Table 7.4, there is a 22% probability that the factor risk-premium accorded by the market to the growth rate factor is zero and an 11% probability that the price accorded to the residual market factor is zero, ie. that the market has not "priced" these factors.

7.2.3 Multifactor models

The models including three and more factors were tested. Although the average adjusted-R^2 values were similar to the one- and two-factor models, there were no models in which all of the factor risk-premiums were significantly different from zero at the 10% level of confidence. A summary of the average adjusted-R^2 values, risk-premiums (λ's) and the related prob>$|T|$ values in parenthesis are presented in Table 7.5.

TABLE 7.5
APT RESULTS FOR THREE- AND MORE FACTOR MODELS ON MINING SHARES

FACTORS	AVG ADJ R^2	RISK-PREMIUMS (PROB>|T|) λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7
123	0.0128	0.01136	-0.0546	-0.1362				
		(0.2217)	(0.4695)	(0.2705)				
124	0.1426	0.00352	-0.0668		0.01576			
		(0.7263)	(0.3537)		(0.0695)			
125	0.0172	0.01008	-0.0667			-0.0254		
		(0.2696)	(0.3643)			(0.9297)		
126	0.0293	0.00484	-0.0414				0.044	
		(0.607)	(0.5966)				(0.0314)	
127	0.5	0.00366	-0.0769					0.00952
		(0.6847)	(0.2881)					(0.0028)
134	0.1406	0.00467		-0.1937	0.02177			
		(0.6641)		(0.1431)	(0.0272)			
135	0.0157	0.01537		-0.1839		-0.2357		
		(0.1428)		(0.1745)		(0.4736)		
136	0.0262	0.00757		-0.143			0.04539	
		(0.4476)		(0.2706)			(0.0298)	
137	0.495	0.00712		-0.1406				0.00893
		(0.4498)		(0.2438)				(0.005)
145	0.1385	0.00213			0.01747	0.15944		
		(0.8532)			(0.0508)	(0.614)		
146	0.1498	0.00245			0.01278		0.04688	
		(0.8222)			(0.1819)		(0.0265)	
147	0.4858	0.00961			0.00241			0.01195
		(0.3617)			(0.8424)			(0.0762)
156	0.0327	0.00638				0.04136	0.04706	
		(0.5215)				(0.8935)	(0.0244)	
157	0.4946	0.00444				0.1205		0.00893
		(0.639)				(0.6778)		(0.019)
167	0.4931	0.00448					0.02621	0.00694
		(0.6145)					(0.2033)	(0.214)
234	0.1432		-0.0405	-0.1727	0.02164			
			(0.5988)	(0.188)	(0.0191)			
235	0.036		-0.0669	-0.0797		0.03737		
			(0.3613)	(0.4834)		(0.8938)		
236	0.0121		-0.0290	-0.0984			0.04983	
			(0.7231)	(0.4352)			(0.0198)	
237	0.4962		-0.0677	-0.919				0.01118
			(0.3564)	(0.4233)				(0.0001)
245	0.1398		-0.0714		0.0164	0.20616		
			(0.3296)		(0.0386)	(0.4713)		
246	0.1514		-0.0405		0.0131		0.04168	
			(0.6)		(0.1269)		(0.0408)	
247	0.4877		-0.0878		0.00527			0.01136
			(0.2419)		(0.6254)			(0.0767)
256	0.0181		-0.0339			0.14176	0.04799	
			(0.6756)			(0.6406)	(0.0208)	
257	0.4956		-0.0843			0.23775		0.01114
			(0.2557)			(0.4103)		(0.0001)

FACTORS	AVG ADJ R^2	RISK-PREMIUMS (PROB>|T|) λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7
267	0.4939		-0.1066				-0.0037	0.01509
			(0.1986)				(0.8804)	(0.0141)
345	0.1386			-0.1921	0.0233	0.14357		
				(0.148)	(0.013)	(0.634)		
346	0.1493			-0.1772	0.01961		0.03765	
				(0.1839)	(0.0431)		(0.0636)	
347	0.4822			-0.1416	0.01637			0.00541
				(0.2827)	(0.1717)			(0.4114)
356	0.0186			-0.1273		0.06011	0.05326	
				(0.334)		(0.85)	(0.0157)	
357	0.4905			-0.1078		0.12617		0.01098
				(0.3445)		(0.6553)		(0.0001)
367	0.4889			-0.1109			0.01336	0.01204
				(0.3315)			(0.5328)	(0.028)
456	0.1485				0.01299	0.15724	0.04786	
					(0.1438)	(0.6077)	(0.0253)	
457	0.4813				0.00866	0.15346		0.00914
					(0.3921)	(0.5805)		(0.1247)
467	0.4829				0.02974		0.17494	-0.0351
					(0.4063)		(0.3113)	(0.4864)
567	0.4884					0.18662	0.02038	0.00989
						(0.5007)	(0.335)	(0.095)
1234	0.141	0.00487	-0.0414	-0.1719	0.02036			
		(0.6503)	(0.5918)	(0.1911)	(0.0389)			
1235	0.0146	0.01402	-0.0408	-0.1595		-0.164		
		(0.172)	(0.6085)	(0.2289)		(0.6113)		
1236	0.0252	0.00769	-0.033	-0.127			0.0404	
		(0.4321)	(0.6788)	(0.3189)			(0.0471)	
1237	0.4985	0.00616	-0.0601	-0.1169				0.00946
		(0.5165)	(0.4219)	(0.3348)				(0.0034)
1245	0.1386	0.00029	-0.0726		0.01717	0.24914		
		(0.9799)	(0.3274)		(0.0637)	(0.4511)		
1246	0.15	0.00289	-0.0409		0.01245		0.04158	
		(0.7879)	(0.5978)		(0.1879)		(0.0422)	
1247	0.4892	0.01012	-0.0959		-0.0013			0.01435
		(0.3625)	(0.2263)		(0.9216)			(0.0527)
1256	0.0318	0.00619	-0.0347			0.07412	0.04278	
		(0.5271)	(0.6628)			(0.8087)	(0.036)	
1257	0.4982	0.00237	-0.0829			0.21902		0.01034
		(0.8091)	(0.2669)			(0.4729)		(0.0106)
1267	0.4966	0.00446	-0.0997				0.00016	0.01306
		(0.6407)	(0.2193)				(0.0349)	(0.9948)
1345	0.1366	0.00258		-0.1882	0.02262	0.12269		
		(0.8362)		(0.1552)	(0.0291)	(0.7208)		
1346	0.1475	0.00378		-0.1772	0.01865		0.03707	
		(0.7314)		(0.1848)	(0.0699)		(0.0681)	
1347	0.4833	0.00866		-0.1096	0.0094			0.00864
		(0.4137)		(0.4001)	(0.4754)			(0.2177)

FACTORS	AVG ADJ R^2	RISK-PREMIUMS (PROB>|T|) λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7
1356	0.03	0.01038		-0.1664		-0.0815	0.04205	
		(0.3286)		(0.2212)		(0.8038)	(0.0455)	
1357	0.4929	0.00804		-0.1454		-0.0049		0.00829
		(0.4352)		(0.2426)		(0.9874)		(0.0368)
1367	0.477	0.0075		-0.1365			0.01357	0.01
		(0.432)		(0.2609)			(0.5364)	(0.0792)
1456	0.147	0.00811			0.00954	-0.0047	0.04811	
		(0.5367)			(0.3693)	(0.9895)	(0.0288)	
1457	0.4827	0.01914			-0.0047	-0.2227		0.01468
		(0.1943)			(0.7485)	(0.5665)	(0.061)	
1467	0.4844	-0.9899			1.3324		4.5054	-1.576
		(0.9778)			(0.9776)		(0.9778)	(0.9776)
1567	0.4911	0.00451				0.12013	0.02593	0.00688
		(0.6379)				(0.6832)	(0.2289)	(0.3009)
2345	0.139		-0.0473	-0.1629	0.02174	0.1799		
			(0.5441)	(0.215)	(0.02)	(0.5528)		
2346	0.1499		-0.0279	-0.1609	0.0189		0.03443	
			(0.7241)	(0.2235)	(0.0495)		(0.087)	
2347	0.4855		-0.07	-0.0821	0.01077			0.00861
			(0.3606)	(0.5313)	(0.3754)			(0.2042)
2356	0.0177		-0.0238	-0.1081		0.09821	0.04865	
			(0.7755)	(0.3997)		(0.7527)	(0.0221)	
2357	0.4942		-0.0733	-0.0836		0.20021		0.01169
			(0.3296)	(0.4735)		(0.4942)		(0.0001)
2367	0.4927		-0.0923	-0.0822			-0.0005	0.0153
			(0.2618)	(0.4995)			(0.9811)	(0.0139)
2456	0.1488		-0.0421		0.01325	0.19929	0.04108	
			(0.5924)		(0.127)	(0.5081)	(0.0441)	
2457	0.4848		-0.0935		0.00543	0.22619		0.01145
			(0.2238)		(0.6166)	(0.4411)		(0.0771)
2467	0.4864		-0.1671		-0.0028		-0.0308	0.02572
			(0.162)		(0.8549)		(0.4327)	(0.075)
2567	0.4926		10.9929			-18.155	5.9661	-1.5986
			(0.9831)			(0.9832)	(0.9831)	(0.983)
3456	0.1473			-0.1768	0.01976	0.13843	0.03756	
				(0.187)	(0.0458)	(0.6521)	(0.0659)	
3457	0.4789			-0.1399	0.01667	0.14337		0.00537
				(0.2919)	(0.168)	(0.6213)		(0.4141)
3467	0.4804			-0.163	0.01835		0.03099	0.00197
				(0.246)	(0.1519)		(0.1933)	(0.83)
3567	0.4869			-0.1011		0.14781	0.01571	0.01185
				(0.3783)		(0.6039)	(0.4691)	(0.0555)
4567	0.4797				0.01074	0.16989	0.03367	0.00465
					(0.293)	(0.8035)	(0.107)	(0.4845)
12345	0.137	0.00216	-0.0471	-0.163	0.02135	0.1639		
		(0.8627)	(0.5476)	(0.2164)	(0.0392)	(0.636)		
12346	0.148	0.00409	-0.0292	-0.1612	0.01789		0.03379	
		(0.7086)	(0.7134)	(0.2241)	(0.0806)		(0.0937)	

FACTORS	AVG ADJ R^2	RISK-PREMIUMS (PROB>|T|) λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7
12347	0.4866	0.00984	-0.082	-0.0513	0.00297			0.01225
		(0.3703)	(0.3039)	(0.7044)	(0.8325)			(0.1055)
12356	0.0293	0.01	-0.021	-0.1506		-0.0484	0.0387	
		(0.3377)	(0.8001)	(0.261)		(0.8812)	(0.0609)	
12357	0.4965	0.00565	-0.0642	-0.1087		0.11111		0.00966
		(0.5833)	(0.4017)	(0.379)		(0.7254)		(0.0174)
12367	0.4951	0.00679	-0.0844	-0.1048			0.00084	0.01317
		(0.499)	(0.3082)	(0.4092)			(0.9725)	(0.0369)
12456	0.1471	0.00626	-0.0365		0.01069	0.07133	0.04161	
		(0.6185)	(0.6472)		(0.2928)	(0.8369)	(0.0447)	
12457	0.4861	0.01447	-0.0939		-0.0045	-0.0448		0.01548
		(0.2961)	(0.259)		(0.7586)	(0.9027)	(0.0488)	
12467	0.4878	0.02144	-0.1958		-0.0185		-0.0436	0.03542
		(0.2916)	(0.2077)		(0.4769)		(0.4176)	(0.1107)
12567	0.4951	-0.0009	-0.1525			0.38077	-0.0203	0.0216
		(0.9396)	(0.1637)			(0.343)	(0.5442)	(0.0426)
13456	0.1453	0.00518		-0.1754	0.01775	0.05663	0.03732	
		(0.6853)		(0.1918)	(0.1047)	(0.8718)	(0.0684)	
13457	0.4799	0.01478		-0.0938	0.00395	-0.1399		0.01074
		(0.2699)		(0.4928)	(0.7868)	(0.6956)		(0.1507)
13467	0.4811	0.01789		0.00325	-0.0061		-0.0217	0.02426
		(0.2345)		(0.9849)	(0.7482)		(0.5394)	(0.0924)
13567	0.4893	0.00816		-0.1437		0.00097	0.02188	0.00736
		(0.431)		(0.2513)		(0.9975)	(0.3298)	(0.2862)
14567	0.4814	-0.0024			0.01958	0.23572	0.07935	-0.0095
		(0.8928)			(0.3195)	(0.6108)	(0.0955)	(0.5694)
23456	0.1479		-0.0329	-0.1552	0.01915	0.17255	0.03367	
			(0.6818)	(0.2403)	(0.0508)	(0.5728)	(0.0952)	
23457	0.4822		-0.0748	-0.0777	0.01102	0.2095		0.00868
			(0.338)	(0.5586)	(0.3704)	(0.4771)		(0.2023)
23467	0.483		-0.1685	0.06676	-0.0033		-0.0308	0.0256
			(0.1792)	(0.7283)	(0.357)		(0.4452)	(0.0947)
23567	0.4900		-0.1254	-0.0534		0.2781	-0.0129	0.02
			(0.1986)	(0.6952)		(0.4225)	(0.6617)	(0.0194)
24567	0.4833		-0.1981		-0.0040	0.298	-0.0394	0.0293
			(0.1673)		(0.8201)	(0.4974)	(0.4035)	(0.0927)
34567	0.4768			-0.1651	0.0187	0.139	0.0323	0.0016
				(0.2489)	(0.1479)	(0.6445)	(0.1876)	(0.8624)
123456	0.1458	0.00439	-0.0282	-0.1608	0.01762	0.09782	0.03431	
		(0.7285)	(0.7277)	(0.2286)	(0.1051)	(0.7801)	(0.0919)	
123457	0.4833	0.01276	-0.0816	-0.045	0.00053	-0.0238		0.01309
		(0.3374)	(0.3221)	(0.7463)	(0.9718)	(0.9465)		(0.0951)
123467	0.4856	0.10835	-17.53	19.391	-1.8487		-7.0658	2.2494
		(0.999)	(0.999)	(0.999)	(0.999)		(0.999)	(0.999)
123567	0.4932	0.00298	-0.1164	-0.0664		0.2352	-0.009	0.01786
		(0.7985)	(0.2252)	(0.634)		(0.517)	(0.731)	(0.0436)
124567	0.4847	0.02141	-0.1916		-0.0181	-0.1029	-0.041	0.03432
		(0.3361)	(0.2134)		(0.4871)	(0.8523)	(0.427)	(0.1089)
134567	0.4774	0.02566		0.01256	-0.0121	-0.341	-0.023	0.02586
		(0.2086)		(0.9475)	(0.5979)	(0.5085)	(0.5555)	(0.1123)

FACTORS	AVG ADJ R^2	RISK-PREMIUMS (PROB>|T|) λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7
234567	0.4807		-8.8666	9.0842	-0.7517	-2.4349	-3.531	1.0744
			(0.971)	(0.9714)	(0.9716)	(0.974)	(0.9713)	(0.9709)
1234567	0.482	-0.0201	14.4441	-1.7309	0.1592	0.5517	0.6	-0.1769
		(0.9147)	(0.844)	(0.834)	(0.834)	(0.8948)	(0.8337)	(0.8478)

In conclusion, the single factor model including the gold price risk appears best able to explain the variation in mining share returns. Although the growth rate risk is also significantly different from zero, the other factors were all insignificant. The two-factor models particularly those with gold price and residual market risk and growth rate and residual market risk appear to be superior to the single factor models due to their average adjusted-R^2 values. However, the two-factor models do not have risk-premiums (λ's) which are significantly different from zero. Thus, although they are superior for modelling purposes, they do not constitute priced APT factors.

7.3 Results of APT tests on Industrial shares

7.3.1 One-factor models

APT models were also developed for the industrial share sample. The tests on the one-factor models were performed using the regression procedures described as the McElroy and Burmeister APT model in 6.2. This yields estimates for b and λ of the form:

$$E(R_{it}) = R_{ft} + b_{ij}\ \lambda_j$$

for share i=1,...n and factor j.

Table 7.6 reports the factor risk-premium, the prob>|T| value in parenthesis and the average adjusted-R^2 value for each model (obtained by calculating a simple average of each of the individual share adjusted-R^2 values).

TABLE 7.6

INDUSTRIAL SHARES: SUMMARY OF APT RESULTS FOR ONE-FACTOR MODELS

Factor	Average adjusted-R^2	λ_j	prob>|T|
1	0.0052	-0.0088	0.0693
2	-0.005	41.3632	0.9377
3	-0.005	0.39157	0.0001
4	-0.005	5.3071	0.8967
5	-0.005	148.462	0.9428
6	-0.004	0.56648	0.2432

The average adjusted-R^2 values are very low compared to their mining share counterparts, and are close to zero. Because these models do not appear to be well-fitted, the details of the share betas are not reported.

7.3.2 Two-factor models

The tests of the APT model were performed on the two-factor models and yielded estimates for b and λ of the form:

$$E(R_{it}) = R_{ft} + b_{ij}\,\lambda_j + b_{ik}\,\lambda_k$$

A summary of the key statistics are presented in Table 7.7.

TABLE 7.7

INDUSTRIAL SHARES: SUMMARY OF APT RESULTS FOR TWO-FACTOR MODELS

Factors	average adjusted-R^2	λ_j (prob>|T|)	λ_k (prob>|T|)
1 & 2	0.0068	0.5 (0.9256)	34.3091 (0.9251)
1 & 3	0.0079	0.04978 (0.0044)	-0.9629 (0.0001)
1 & 4	0.0013	0.1238 (0.5399)	1.017 (0.5008)
1 & 5	0.0095	0.2087 (0.2419)	-8.4163 (0.2313)
1 & 6	0.0165	2.5988 (0.9203)	-5.105 (0.9206)
1 & 7	0.1801	-0.0187 (0.0009)	0.02273 (0.0001)
2 & 3	0.0041	49.3385 (0.9534)	-54.34 (0.9533)
2 & 4	0.0102	37.7391 (0.9335)	0.9844 (0.9332)
2 & 5	-0.007	4.5462 (0.7283)	-27.841 (0.7181)
2 & 6	-0.005	32.0738 (0.936)	4.7928 (0.9358)
2 & 7	0.1779	14.5318 (0.8308)	-0.2597 (0.8407)
3 & 4	0.0011	-0.7981 (0.0004)	0.12084 (0.0006)
3 & 5	-0.006	29.549 (0.9973)	-223.12 (0.9973)
3 & 6	0.001	-0.8433 (0.0164)	0.2333 (0.0086)
3 & 7	0.178	-0.4674 (0.0001)	0.02216 (0.0001)
4 & 5	0.013	0.1499 (0.0679)	-5.2519 (0.0555)
4 & 6	0.0193	3.5763 (0.9165)	-4.6576 (0.917)

4 & 7	0.1721	-0.1507 (0.0017)	0.06427 (0.0002)
5 & 6	0	166.278 (0.9963)	-0.27 (0.9967)
5 & 7	0.1821	-3.016 (0.0025)	0.0277 (0.0148)
6 & 7	0.1729	-0.3432 (0.132)	0.11764 (0.0862)

A distinguishing feature of these results is the extremely low average adjusted-R^2 values for all models which exclude the residual market factor. The average adjusted-R^2 values for models including the residual market risk factor are very similar to each other. Three models also have risk-premiums which are significantly different from zero at the 1% level of confidence. The individual share beta estimates, the t-ratios and related prob>¦T¦ values, as well as the adjusted-R^2 value for each share in the industrial sample are reported in Table 7.8 (for a model containing factors 4 and 7). Appendix C reports the results for a model containing factors 1 and 7 and Appendix D contains the results for a model containing factors 3 and 7.

7.3.2.1 Results for the model with gold price risk and residual market risk

TABLE 7.8

INDUSTRIAL SHARES: APT RESULTS FOR GOLD PRICE RISK AND THE RESIDUAL MAKRET RISK (FACTORS 4 & 7)

The equation that was used is:

$$r_{it} = r_{ft} + b_{i4}\lambda_4 + b_{i4}f_{4t} + b_{i7}\lambda_7 + b_{i7}f_{7t} + \epsilon_{it}$$

The APT equation that was estimated by the McElroy and Burmeister model is:

$$E(r_{it}) = R_{ft} + b_{i4}\ -0.1507 + b_{i7}\ 0.06427$$

share	b estimate	t-value	prob>|T|	Adjusted-R^2
liberty				0.2796
b4	0.214346	3.56	0.0005	
b7	0.717976	6.93	0.0001	
malbak				0.2062
b4	0.329396	3.91	0.0002	
b7	0.832810	5.64	0.0001	
mccarthy				0.0875
b4	0.172122	1.84	0.0681	
b7	0.647920	3.72	0.0003	
nampak				0.2099
b4	0.198455	3.44	0.0008	
b7	0.591866	5.78	0.0001	
ok				0.1983
b4	0.287726	4.24	0.0001	
b7	0.626196	5.38	0.0001	
pepkor				0.1041
b4	0.145784	1.59	0.1144	
b7	0.674149	4.00	0.0001	
picknpay				0.2631
b4	0.239492	3.43	0.0008	
b7	0.812790	6.73	0.0001	
pioneer				0.1527
b4	0.210144	3.52	0.0006	
b7	0.492232	4.61	0.0001	
powertech				0.1212
b4	0.248440	2.65	0.0091	
b7	0.722707	4.18	0.0001	
ppc				0.0853
b4	0.096508	1.55	0.1247	
b7	0.419310	3.61	0.0004	

premier				0.0874
b4	0.230637	2.80	0.0059	
b7	0.557097	3.67	0.0004	
rembrandt				0.3527
b4	0.209197	2.98	0.0036	
b7	0.947507	8.45	0.0001	
barlows				0.4680
b4	0.301187	5.32	0.0001	
b7	0.882128	10.16	0.0001	
blue-circle				0.1343
b4	0.226207	2.96	0.0037	
b7	0.637354	4.57	0.0001	
clicks				0.1471
b4	0.230583	2.86	0.0050	
b7	0.706009	4.81	0.0001	
sa-brews				0.3805
b4	0.231727	4.13	0.0001	
b7	0.795115	8.73	0.0001	
amic				0.3546
b4	0.328310	4.67	0.0001	
b7	0.937743	8.11	0.0001	
sanland				0.0669
b4	0.147358	2.69	0.0081	
b7	0.310827	3.07	0.0026	
sappi				0.2190
b4	0.259308	3.29	0.0013	
b7	0.842683	6.06	0.0001	
sasol				0.4155
b4	0.314509	5.39	0.0001	
b7	0.813159	8.89	0.0001	
seardel				0.0550
b4	0.109642	1.16	0.2467	
b7	0.535567	3.03	0.0030	
avi				0.1579
b4	0.177726	2.67	0.0088	
b7	0.626393	5.21	0.0001	
aeci				0.2612
b4	0.237156	3.91	0.0002	
b7	0.694706	6.62	0.0001	
afcol				0.1613
b4	0.252632	3.33	0.0011	
b7	0.686741	5.04	0.0001	
afrox				0.1996
b4	0.219823	3.14	0.0021	
b7	0.702671	5.62	0.0001	
amaprop				0.0199
b4	0.159700	0.94	0.3482	
b7	0.699807	2.17	0.0324	
anglo-alpha				0.1172
b4	0.117880	1.98	0.0500	
b7	0.477964	4.38	0.0001	

tiger-oats				0.2825
b4	0.187996	3.31	0.0013	
b7	0.691422	7.13	0.0001	
tongaat				0.3131
b4	0.277739	4.62	0.0001	
b7	0.748934	7.47	0.0001	
dorbyl				0.2674
b4	0.284749	4.05	0.0001	
b7	0.807715	6.66	0.0001	
hiveld				0.1635
b4	0.267806	3.30	0.0013	
b7	0.722273	4.93	0.0001	
fedfund				0.2087
b4	0.266838	4.20	0.0001	
b7	0.590591	5.39	0.0001	
gf-props				0.2463
b4	0.330107	4.53	0.0001	
b7	0.737188	6.00	0.0001	
santam				0.1357
b4	0.209258	2.83	0.0055	
b7	0.603786	4.46	0.0001	
sbic				0.2252
b4	0.223830	3.47	0.0007	
b7	0.671072	5.89	0.0001	
sentrachem				0.2062
b4	0.373102	4.28	0.0001	
b7	0.819272	5.48	0.0001	
abercom				0.1236
b4	0.331527	3.64	0.0004	
b7	0.676422	4.19	0.0001	
boland				-0.0156
b4	0.067241	1.61	0.1105	
b7	0.115591	1.46	0.1481	
btr-dunlop				0.1584
b4	0.188114	2.75	0.0068	
b7	0.609200	4.91	0.0001	
goldstein				0.0703
b4	0.266675	2.50	0.0138	
b7	0.635023	3.19	0.0018	
metkor				0.1380
b4	0.226236	2.73	0.0073	
b7	0.693575	4.57	0.0001	
nedcor				0.1982
b4	0.248211	3.83	0.0002	
b7	0.614241	5.38	0.0001	
prima				0.0693
b4	0.151022	2.70	0.0080	
b7	0.304439	2.95	0.0039	
romatex				0.0756
b4	0.169919	2.71	0.0077	
b7	0.408735	3.53	0.0006	

fedfood				0.1201
b4	0.206170	3.01	0.0032	
b7	0.517474	4.12	0.0001	
bankorp				0.1925
b4	0.268661	4.08	0.0001	
b7	0.596048	5.22	0.0001	
concor				0.0027
b4	0.101472	0.98	0.3278	
b7	0.256825	1.29	0.1986	
i&j				0.1282
b4	0.142991	2.01	0.0462	
b7	0.593063	4.59	0.0001	
ics				0.1232
b4	0.196988	2.82	0.0057	
b7	0.548439	4.27	0.0001	
kanhym				0.0684
b4	0.278557	2.80	0.0061	
b7	0.586467	3.20	0.0018	
lta				0.0535
b4	0.243113	2.77	0.0065	
b7	0.415473	2.59	0.0108	
otis				0.0905
b4	0.199991	2.79	0.0062	
b7	0.450062	3.40	0.0009	

The signs of the beta coefficients are all positive, and the sign of λ_4 is negative. Although the beta coefficients and adjusted-R^2 values are fairly high, they are much lower than the beta coefficients and adjusted-R^2 values for the mining sector tests on factors 4 and 7. Furthermore, the larger and more diversified companies such as Barlows and AMIC are particularly sensitive to gold price risk. In addition, Sentrachem and Sasol, both chemical manufacturers are very sensitive to factor 4, possibly because a large portion of their operations involve the supply of chemicals to the mining industry.

7.3.2.2 Results for the model with foreign exchange risk and residual market risk

The results in Appendix C show that there are several high beta values for factor 1 which indicates that these shares are very sensitive to this factor. This would indicate that a deterioration in the rand-dollar exchange rate would impact adversely on these industrial share returns. The negative betas are generally not significantly different from zero although a negative relationship between foreign exchange risk and these share returns is plausible. For example, Rembrandt is widely perceived to be a "rand hedge" due to its extended international operations. Hiveld is a steel manufacturer for which a major source of revenue would be exports, and so a depreciation in the exchange rate would improve its profits.

7.3.2.3 Results for model with inflation risk and residual market risk

The results for the model including inflation risk and the residual market risk are presented in Appendix D. The beta coefficients for inflation risk are low, indicating that shares are not highly sensitive to inflation risk. Furthermore, the risks are priced since the t-statistics for λ_3 and λ_7 are significantly different from zero at 1%.

7.3.3 Three-factor models

The APT model tests on the three-factor models were run and produced estimates for b's and λ's of the form:

$$E(R_{it}) = \lambda_{0t} + b_{ij}\,\lambda_j + b_{ik}\,\lambda_k + b_{il}\,\lambda_l$$

for share i=1,...n and factors j,k and l.

Table 7.9 reports the factor risk-premiums, the prob>¦T¦ value in parenthesis and average adjusted-R^2 values for each model.

TABLE 7.9

SUMMARY OF APT RESULTS FOR THREE-FACTOR MODELS

Factors	Average adjusted-R^2	λ_j (prob>¦T¦)	λ_k (prob>¦T¦)	λ_l (prob>¦T¦)
1,2 & 3	0.0071	2.5804 (0.9517)	40.7628 (0.9517)	-56.265 (0.9516)
1,2 & 4	0.0175	0.3172 (0.8893)	22.6152 (0.8876)	0.07017 (0.913)
1,2 & 5	0.0065	3.5197 (0.9462)	17.954 (0.9464)	-142 (0.9461)
1,2 & 6	0.0138	-0.0473 (0.8564)	0.6959 (0.7954)	0.1 (0.7805)
1,2 & 7	0.18	-0.0221 (0.7888)	-0.0148 (0.9824)	0.01716 (0.6545)
1,3 & 4	0.0185	0.0598 (0.0083)	-1.0809 (0.0008)	0.08328 (0.0074)
1,3 & 5	0.0075	0.17534 (0.1511)	-0.6215 (0.2037)	-6.4672 (0.143)
1,3 & 6	0.015	10.4527 (0.9799)	-32.082 (0.9798)	-20.301 (0.9799)
1,3 & 7	0.1809	-1.0994 (0.8059)	14.0617 (0.8079)	0.2044 (0.7932)
1,4 & 5	0.021	0.23614 (0.2975)	0.11393 (0.353)	-9.5108 (0.2885)
1,4 & 6	0.027	2.0021 (0.9097)	1.9094 (0.9093)	-4.4158 (0.91)
1,4 & 7	0.1777	-0.0343 (0.0274)	-0.148 (0.0017)	0.0634 (0.0002)
1,5 & 6	0.0147	-4.6728 (0.9975)	184.797 (0.9975)	4.7613 (0.9975)
1,5 & 7	0.1863	7.804 (0.9984)	-306.81 (0.9984)	-1.4058 (0.9984)
1,6 & 7	0.1822	1.4116 (0.8841)	-3.7627 (0.8843)	0.7021 (0.8813)
2,3 & 4	0.0111	40.048 (0.9467)	-49.396 (0.9465)	2.8547 (0.9465)
2,3 & 5	-0.078	23.288 (0.9369)	-36.947 (0.9366)	78.269 (0.9367)
2,3 & 6	-0.0003	45.1956 (0.9555)	-47.812 (0.9554)	6.366 (0.9554)
2,3 & 7	0.1776	29.285 (0.9255)	-34.688 (0.9251)	-0.2319 (0.931)

2,4 & 5	0.0098	17.0999 (0.9269)	2.6956 (0.9263)	-105.87 (0.9265)
2,4 & 6	0.0154	13.488 (0.8574)	-0.7467 (0.8591)	1.9779 (0.8563)
2,4 & 7	0.1703	-0.3759 (0.001)	-0.094 (0.001)	0.0527 (0.0001)
2,5 & 6	-0.004	13.616 (0.9148)	-93.393 (0.9143)	-1.7407 (0.9154)
2,5 & 7	0.1806	56.0308 (0.9755)	-315.35 (0.9754)	-0.0169 (0.9913)
2,6 & 7	0.1778	-0.7337 (0.0065)	-0.1395 (0.0207)	0.0702 (0.0033)
3,4 & 5	0.0109	0.383 (0.4761)	0.1744 (0.2122)	-8.0553 (0.1962)
3,4 & 6	0.0189	-1.3788 (0.9039)	3.354 (0.9049)	-3.978 (0.9056)
3,4 & 7	0.1707	0.05247 (0.7346)	-0.1616 (0.0031)	0.06671 (0.0004)
3,5 & 6	0.0016	11.2729 (0.924)	-100.16 (0.9232)	-3.569 (0.9237)
3,5 & 7	0.181	0.1686 (0.4933)	-4.356 (0.0257)	0.0292 (0.0685)
3,6 & 7	0.1786	0.178 (0.6085)	-0.3281 (0.1248)	0.1132 (0.0757)
4,5 & 6	0.0169	-1.672 (0.9962)	145.45 (0.9961)	0.2178 (0.9959)
4,5 & 7	0.1745	-0.0085 (0.9696)	-1.559 (0.7975)	0.0219 (0.7749)
4,6 & 7	0.1724	-0.0002 (0.9586)	-0.2946 (0.9587)	0.0875 (0.9578)
5,6 & 7	0.181	-4.1874 (0.0841)	-0.2388 (0.1042)	0.0841 (0.057)

Consistent with the results from the two-factor models, those models that include the residual market risk factor (factor 7) have higher average adjusted-R^2 values than the other models. The averaged adjusted-R^2 values for the models including factor 7 are very similar indicating that they are equal in terms of explaining the variation in returns. Only one model has risk-premiums which are all significantly different from zero at the 1% level. This model includes the default risk (factor 2), gold price risk (factor

4) and the residual market risk (factor 7) and the results of he test for this model are reported in Appendix E.

7.3.3.1 Results for model with default premium risk, gold price risk and residual market risk

The increase in explanatory power attributable to the default premium risk appears to be low. Although it is priced as significantly different from zero at the 1% level, the beta coefficients are low and generally not significant with only 5 of the betas relating to default risk being significant at the 5% level and none at the 1% level. The beta for gold price risk (b_4) and for the residual market risk (b_7) are very similar to those obtained in the model including only those two factors. Consequently, the simpler model with only two factors, namely gold price risk and residual market risk, is preferred.

7.3.4 Multifactor models

The models including four and more factors were tested. The average adjusted-R^2 values were similar to the two- and three-factor models, but there were no models in which all of the factor risk-premiums were significantly different from zero at the 1% level of confidence. Table 7.10 contains a summary of the average adjusted-R^2 values, the risk-premiums (λ's) and the related prob>$|T|$ values in parenthesis.

TABLE 7.10
INDUSTRIAL SHARES
APT RESULTS FOR MODELS INCLUDING FOUR OR MORE FACTORS

FACTORS	AVG ADJ R^2	RISK-PREMIUMS (PROB>|T|) λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7
1234	0.0172	2.383	37.429	-51.56	1.5388			
		(0.9477)	(0.9478)	(0.9476)	(0.9476)			
1235	0.0047	1.6843	13.381	-14.47		-54.84		
		(0.8889)	(0.8893)	(0.8882)		(0.8888)		
1236	0.0138	4.2984	32.597	-54.956			-2.9827	
		(0.0955)	(0.9551)	(0.955)			(0.9553)	
1237	0.1809	1.7841	23.827	-29.179				-0.6778
		(0.9203)	(0.9204)	(0.92)				(0.9221)
1245	0.0181	3.4257	17.486		1.5323	-138.97		
		(0.9452)	(0.9454)		(0.945)	(0.9452)		
1246	0.024	0.0689	0.1933		0.052		-0.0848	
		(0.7598)	(0.7548)		(0.7573)		(0.7607)	
1247#	0.1762	-0.0263	-0.376		-0.0855			0.0506
		(0.022)	(0.0007)		(0.001)			(0.0001)
1256	0.0122	4.1711	1.3788			-135.69	-6.64	
		(0.9534)	(0.9563)			(0.9523)	(0.9525)	
1257	0.1848	5.2259	12.76			-198.61		-1.063
		(0.9614)	(0.9617)			(0.9614)		(0.962)
1267	0.1803	0.0534	-0.864				-0.1982	0.0743
		(0.1204)	(0.0314)				(0.0573)	(0.0204)
1345	0.0189	0.1949		-0.6563	0.1024	-7.179		
		(0.192)		(0.242)	(0.2544)	(0.1847)		
1346	0.0296	1.405		-5.0219	1.3558		-2.559	
		(0.8532)		(0.8505)	(0.8524)		(0.8541)	
1347	0.1762	-0.0526		0.2548	-0.191			0.07558
		(0.0313)		(0.2408)	(0.0094)			(0.0022)
1356	0.0129	0.6462		-0.9275		-19.414	-0.996	
		(0.6901)		(0.7023)		(0.6897)	(0.6953)	
1357	0.1848	3.4438		-9.7		-122.8		-0.5972
		(0.9381)		(0.9375)		(0.9381)		(0.9397)
1367	0.1809	0.1785		-0.7382			-0.3604	0.0863
		(0.2164)		(0.2389)			(0.2256)	(0.1633)
1456	0.0252	1.9833			1.263	-62.533	-3.326	
		(0.8995)			(0.899)	(0.8994)	(0.8999)	
1457	0.1813	-2.2985			-1.696	85.677		0.3343
		(0.911)			(0.9113)	(0.9111)		(0.9072)
1467	0.1765	2.6979			1.4209		-7.005	0.9609
		(0.9381)			(0.9381)		(0.9382)	(0.937)
1567	0.1848	0.4067				-13.429	-0.7117	0.1096
		(0.5714)				(0.568)	(0.5772)	(0.5376)
2345	0.01		0.0652	-1.798	-0.0688	6.5536		
			(0.2617)	(0.2271)	(0.4405)	(0.2377)		
2346	0.0151		30.004	-32.413	0.1806		4.086	
			(0.9325)	(0.9322)	(0.9348)		(0.9322)	

= significant at the 5% level

FACTORS	AVG ADJ R^2	RISK-PREMIUMS (PROB>|T|) λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7
2347	0.1694		0.2595	-0.2471	-0.0295			0.01966
			(0.8015)	(0.8258)	(0.855)			(0.7328)
2356	-0.04		9.5045	-13.089		32.99	1.686	
			(0.8549)	(0.8532)		(0.8538)	(0.8533)	
2357	0.1796		0.0658	-0.0128		-2.0366		0.0141
			(0.9611)	(0.9935)		(0.8109)		(0.7907)
2367	0.1772		-1.0346	0.6537			-0.1845	0.0808
			(0.0353)	(0.1213)			(0.0648)	(0.0223)
2456	0.0134		-0.8197		0.4459	-11.693	-0.7167	
			(0.5486)		(0.5328)	(0.5363)	(0.5444)	
2457	0.1724		-0.0119		-0.0216	-1.9119		0.0356
			(0.8983)		(0.2416)	(0.0006)		(0.0002)
2467	0.171		-0.6337		-0.0345		-0.0945	0.0602
			(0.0017)		(0.1643)		(0.016)	(0.0005)
2567#	0.1795		-0.5782			-1.7259	-0.152	0.0688
			(0.0157)			(0.0345)	(0.0254)	(0.0053)
3456	0.0156			9.785	3.3339	-110.52	-6.095	
				(0.9429)	(0.9421)	(0.9422)	(0.9424)	
3457	0.1727			0.1575	-0.0256	-2.81		0.0395
				(0.3683)	(0.316)	(0.0044)		(0.0032)
3467	0.1711			0.5713	-0.016		-0.374	0.1069
				(0.3248)	(0.7695)		(0.1761)	(0.116)
3567	0.1797			0.3898		-5.5112	-0.319	0.0995
				(0.4499)		(0.1842)	(0.2052)	(0.1411)
4567	0.1755				0.0797	-4.8518	-0.2756	0.0643
					(0.2574)	(0.1306)	(0.1521)	(0.1005)
12345	0.0161	1.8645	14.8373	-15.097	1.028	-60.827		
		(0.9)	(0.9003)	(0.8994)	(0.8994)	(0.8999)		
12346	0.023	3.4484	22.732	-39.926	2.999		-2.7787	
		(0.9421)	(0.9422)	(0.9419)	(0.942)		(0.9425)	
12347*	0.1758	-0.0835	-1.185	1.335	-0.1327			0.0736
		(0.0856)	(0.0545)	(0.0886)	(0.0977)			(0.0344)
12356	0.011	1.5651	2.3635	-3.9825		-47.025	-2.212	
		(0.8677)	(0.8729)	(0.8659)		(0.8677)	(0.8686)	
12357	0.1837	3.0268	19.7434	-21.967		-91.197		-0.6938
		(0.9351)	(0.9354)	(0.9349)		(0.9351)		(0.9366)
12367	0.1798	0.05027	0.27774	-0.5358			-0.0575	0.0151
		(0.8552)	(0.8814)	(0.8411)			(0.8643)	(0.8699)
12456	0.0227	3.9386	2.1859		2.3285	-129.30	-6.0768	
		(0.9497)	(0.9519)		(0.9596)	(0.9497)	(0.9498)	
12457	0.18	-0.1701	-1.153		-0.1448	6.2505		0.064
		(0.1801)	(0.166)		(0.2283)	(0.1793)		(0.1393)
12467	0.1765	0.0321	-0.7246		-0.0286		-0.1452	0.0675
		(0.1598)	(0.011)		(0.3517)		(0.0312)	(0.0049)
12567	0.1833	0.3264	-0.4367			-10.712	-0.5888	0.1
		(0.4997)	(0.5752)			(0.4952)	(0.5047)	(0.4528)

* = significant at the 10% level

\# = significant at the 5% level

FACTORS	AVG ADJ R^2	RISK-PREMIUMS (PROB>|T|) λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7
13456	0.0236	0.66842		-0.9858	0.4349	-19.901	-1.029	
		(0.7006)		(0.7096)	(0.6991)	(0.7002)	(0.7054)	
13457	0.1797	-1.368		4.0479	-1	46.162		0.235
		(0.8448)		(0.8496)	(0.8458)	(0.845)		(0.8352)
13467	0.1765	0.2077		-0.7012	0.0944		-0.4303	0.0809
		(0.2877)		(0.3246)	(0.3858)		(0.2953)	(0.2298)
13567	0.1833	0.2686		-0.4668		-8.2494	-0.4328	0.0751
		(0.3828)		(0.505)		(0.3787)	(0.3971)	(0.3397)
14567	0.1766	0.2808			0.0882	-9.4201	-0.5142	0.0967
		(0.4417)			(0.5496)	(0.4345)	(0.4489)	(0.391)
23456	0.0136		3.0777	-3.7833	-0.164	11.728	0.407	
			(0.5631)	(0.5494)	(0.6014)	(0.5539)	(0.5497)	
23457*	0.1708		-0.4989	0.6309	-0.0555	-1.9088		0.0508
			(0.0116)	(0.031)	(0.0798)	(0.0153)		(0.002)
23467	0.1699		-0.8875	0.6386	-0.0503		-0.1237	0.0702
			(0.014)	(0.0666)	(0.1653)		(0.0469)	(0.0063)
23567	0.1785		-0.8362	0.6081		-2.2388	-0.205	0.0793
			(0.0543)	(0.1576)		(0.0873)	(0.0772)	(0.031)
24567	0.1848		-0.5809		-0.0147	-1.0346	-0.1164	0.0587
			(0.0048)		(0.5521)	(0.0565)	(0.016)	(0.0012)
34567	0.172			0.66098	0.0845	-6.7408	-0.3886	0.0847
				(0.4176)	(0.403)	(0.2743)	(0.2932)	(0.2234)
123456	0.0216	1.35545	1.7266	-3.2763	0.8755	-40.297	-1.945	
		(0.8484)	(0.8573)	(0.8462)	(0.8474)	(0.8483)	(0.8496)	
123457	0.1787	3.7987	18.127	-22.939	2.2966	-107.56		-0.9305
		(0.9964)	(0.9964)	(0.9964)	(0.9964)	(0.9964)		(0.9964)
123467	0.1751	0.0286	-0.8383	0.4731	-0.0339		-0.157	0.0712
		(0.2416)	(0.0216)	(0.1366)	(0.333)		(0.0471)	(0.0099)
123567	0.1821	0.3679	0.0709	-0.6868		-11.260	-0.583	0.0896
		(0.5212)	(0.9172)	(0.5774)		(0.5193)	(0.5289)	(0.4756)
124567	0.1791	0.149	-0.5338		0.0379	-4.8995	-0.3102	0.0767
		(0.2213)	(0.2412)		(0.5546)	(0.207)	(0.220[illegible]	(0.1498)
134567	0.1794	0.2288		-0.2849	0.0808	-7.221	-0.388	0.07548
		(0.3338)		(0.5988)	(0.4638)	(0.3275)	(0.3475)	(0.2784)
234567	0.1712		-0.8401	0.6735	-0.033	-1.2636	-0.1508	0.0698
			(0.025)	(0.0845)	(0.355)	(0.1117)	(0.053)	(0.0115)
1234567	0.1775	0.1613	-0.4549	0.0932	0.048	-5.177	-0.3176	0.0742
		(0.2354)	(0.305)	(0.829)	(0.495)	(0.225)	(0.2405)	(0.1653)

* = significant at the 10% level

7.4 A seemingly unrelated regression model (SUR)

In addition to the APT tests that were developed in the previous section, a seemingly unrelated regression model of the form:

$$(R_{it} - R_{ft}) = \beta_{0i} + \beta_{1i} f_{1t} + \ldots\ldots + \beta_{ki} f_{kt} + e_{it}$$

for i=1...N and t=1....T was run against the following factor sets for mining shares:

1. gold price risk (factor 4) reported in Table 7.11;
2. growth rate risk (factor 6) reported in Appendix F;
3. gold price risk and residual market risk (factors 4 and 7) reported in Table 7.12;
4. growth rate risk and residual market risk (factors 6 and 7) reported in Appendix G;

and the following factor sets for industrial shares:

1. gold price risk and residual market risk (factors 4 and 7) reported in Table 7.13;
2. foreign exchange risk and residual market risk (factors 1 and 7) reported in Appendix H;
3. inflation risk and residual market risk (factors 3 and 7) reported in Appendix I;
4. default premium risk, gold price risk and residual market risk (factors 2, 4 and 7) reported in Appendix J.

where: $(R_{it}-R_{ft})$ = excess return on share i for period t;
β_{0i} = an intercept term;
β_{ki} = the beta coefficient for share i and for factor k;
f_{kt} = factor k as measured at time t;
e_{it} = error term for share i at time t.

The error terms (e_{it}) are assumed to be normally distributed with a zero mean and a variance equal to σ_i^2 and the covariance between the error terms of shares i and j that is assumed to be given by σ_{ij}^2. The average adjusted-R^2 values for each model, the model estimates and the prob>|T| values (in parentheses) are reported for the same models as reported under the APT tests.

TABLE 7.11

MINING SHARES: SEEMINGLY UNRELATED REGRESSION MODEL FOR GOLD PRICE RISK

share	β-estimates	t-value	prob>|T|	adjusted-R^2
kinross				0.1995
β_0	0.0205	1.68	0.0954	
β_4	0.9732	5.45	0.0001	
kloof				0.1950
β_0	0.0156	1.69	0.0946	
β_4	0.7396	5.43	0.0001	
minorco				0.0485
β_0	0.0188	1.58	0.1168	
β_4	0.4714	2.70	0.0080	
palamin				0.0750
β_0	0.0061	0.78	0.4365	
β_4	0.3632	3.18	0.0019	
randfontein				0.2532
β_0	0.0168	1.63	0.1057	
β_4	0.9591	6.35	0.0001	
rusplat				0.1934
β_0	0.0249	2.40	0.0181	
β_4	0.8160	5.36	0.0001	
southvaal				0.1665
β_0	0.0174	1.73	0.0866	
β_4	0.7309	4.95	0.0001	
amcoal				-0.0051
β_0	0.0037	0.40	0.6898	
β_4	0.0597	0.44	0.6606	
samancor				0.0263
β_0	0.0126	1.13	0.2615	
β_4	0.3228	1.97	0.0511	
anglo				0.2021
β_0	0.0163	2.01	0.0465	
β_4	0.6573	5.53	0.0001	
implats				0.1198
β_0	0.0231	2.00	0.0479	
β_4	0.6968	4.12	0.0001	
trans-natal				0.0157
β_0	-0.003	-0.34	0.7339	
β_4	0.2191	1.67	0.0975	

debeers				0.0757
β_0	0.0126	1.41	0.1624	
β_4	0.4283	3.26	0.0015	
dries				0.1623
β_0	0.01	1.22	0.2262	
β_4	0.5892	4.87	0.0001	
et-cons				0.1975
β_0	0.0243	2.31	0.0228	
β_4	0.8471	5.48	0.0001	
ergo				0.2069
β_0	0.0119	1.05	0.2971	
β_4	0.9386	5.63	0.0001	
harties				0.2290
β_0	0.0166	1.72	0.0887	
β_4	0.8540	6.02	0.0001	
genbel				0.1257
β_0	0.0168	1.63	0.1059	
β_4	0.6423	4.25	0.0001	
gencor				0.1889
β_0	0.0129	1.59	0.1135	
β_4	0.6302	5.33	0.0001	
goldfields SA				0.1210
β_0	0.0190	1.66	0.1002	
β_4	0.6976	4.15	0.0001	
		Average	adjusted-R^2	0.1398

The average adjusted-R^2 value for the SUR model with gold price risk is 0.1398, compared to 0.1444 which was reported by the APT tests. The SUR model thus does not appear to predict returns better than the APT. The individual share adjusted-R^2 values are similar to the APT results.

7.4.1 Results for growth rate risk

The results for the SUR model including growth rate risk is presented in Appendix F. The average adjusted-R^2 value for the SUR model is 0.0089, compared to the 0.0154 obtained from the APT tests. The adjusted-R^2 values are similar and the SUR model does not appear to perform better than the APT model.

7.4.2 Results for model with gold price and residual market risk

TABLE 7.12
MINING SHARES: SEEMINGLY UNRELATED REGRESSION MODEL FOR GOLD PRICE RISK AND RESIDUAL MARKET RISK

share	β-estimates	t-value	prob>|T|	adjusted-R^2
kinross				0.5987
β_0	0.0205	2.37	0.0192	
β_4	0.9732	7.70	0.0001	
β_7	1.5261	10.83	0.0001	
kloof				0.5387
β_0	0.0156	2.23	0.0279	
β_4	0.7396	7.18	0.0001	
β_7	1.0786	9.39	0.0001	
minorco				0.2983
β_0	0.0188	1.84	0.0683	
β_4	0.4714	3.14	0.0021	
β_7	1.0925	6.53	0.0001	
palamin				0.2916
β_0	0.0061	0.89	0.3741	
β_4	0.3632	3.63	0.0004	
β_7	0.6767	6.06	0.0001	
randfontein				0.5996
β_0	0.0168	2.23	0.0279	
β_4	0.9590	8.67	0.0001	
β_7	1.2463	10.11	0.0001	
rusplat				0.5664
β_0	0.0249	3.27	0.0014	
β_4	0.8160	7.31	0.0001	
β_7	1.2555	10.08	0.0001	
southvaal				0.5053
β_0	0.0174	2.24	0.0268	
β_4	0.7309	6.42	0.0001	
β_7	1.1434	9.01	0.0001	
amcoal				0.2000
β_0	0.0037	0.45	0.6546	
β_4	0.0597	0.49	0.6226	
β_7	0.7515	5.57	0.0001	

samancor				0.1357
β_0	0.0126	1.20	0.2335	
β_4	0.3228	2.09	0.0386	
β_7	0.6839	3.98	0.0001	
anglo				0.7655
β_0	0.0163	3.71	0.0003	
β_4	0.6573	10.20	0.0001	
β_7	1.2068	16.80	0.0001	
implats				0.5305
β_0	0.0231	2.74	0.0072	
β_4	0.6968	5.64	0.0001	
β_7	1.4005	10.17	0.0001	
trans-natal				0.1621
β_0	-0.0031	-0.37	0.7125	
β_4	0.2191	1.81	0.0728	
β_7	0.625	4.63	0.0001	
debeers				0.5838
β_0	0.0126	2.10	0.0383	
β_4	0.4283	4.85	0.0001	
β_7	1.1803	11.99	0.0001	
dries				0.5171
β_0	0.100	1.60	0.1118	
β_4	0.5892	6.42	0.0001	
β_7	0.9541	9.33	0.0001	
et-cons				0.5192
β_0	0.0243	2.98	0.0035	
β_4	0.8471	7.07	0.0001	
β_7	1.1888	8.90	0.0001	
ergo				0.4317
β_0	0.0119	1.24	0.2185	
β_4	0.9386	6.65	0.0001	
β_7	1.0822	6.88	0.0001	
harties				0.6201
β_0	0.166	2.45	0.0160	
β_4	0.8540	8.57	0.0001	
β_7	1.2242	11.02	0.0001	
genbel				0.5498
β_0	0.0168	2.27	0.0250	
β_4	0.6423	5.92	0.0001	
β_7	1.2764	10.55	0.0001	
gencor				0.6495
β_0	0.0128	2.43	0.0168	
β_4	0.6302	8.11	0.0001	
β_7	1.0776	12.44	0.0001	
goldfields SA				0.5709
β_0	0.0189	2.37	0.0194	
β_4	0.6976	5.94	0.0001	
β_7	1.4549	11.12	0.0001	
		Average	adjusted-R^2	0.4817

The average adjusted-R^2 value for the SUR model is 0.4817, compared to the APT model adjusted-R^2 of 0.4843. Since there is not much difference in the adjusted-R^2 values of the two models, it would seem that the APT model is as useful for forecasting purposes as the seemingly unrelated regression models.

7.4.3 Results for model with growth rate and residual market risk

The average adjusted-R^2 for the SUR model reported in Appendix G (growth rate risk and residual market risk) is 0.4877 compared to the APT model's adjusted-R^2 of 0.4903. Once again the APT and the SUR would seem to produce equally well-fitted models.

TABLE 7.13

INDUSTRIAL SHARES: SEEMINGLY UNRELATED REGRESSION MODEL FOR GOLD PRICE RISK AND RESIDUAL MARKET RISK

share	β-estimates	t-value	prob>|T|	adjusted-R^2
liberty				0.2741
β_0	0.0147	2.15	0.0335	
β_4	0.2381	2.38	0.0190	
β_7	0.7058	6.23	0.0001	
malbak				0.2034
β_0	0.0071	0.73	0.4666	
β_4	0.4186	2.94	0.0040	
β_7	0.7872	4.95	0.0001	
mccarthy				0.0911
β_0	0.0095	0.83	0.4077	
β_4	0.0029	0.02	0.9864	
β_7	0.7344	3.91	0.0002	
nampak				0.2034
β_0	0.0082	1.21	0.2279	
β_4	0.2009	2.02	0.0453	
β_7	0.5906	5.34	0.0001	
ok				0.1920
β_0	-0.0039	-0.52	0.6062	
β_4	0.265	2.36	0.0200	
β_7	0.6378	5.09	0.0001	
pepkor				0.0994
β_0	0.0184	1.65	0.1021	
β_4	0.064	0.39	0.6961	
β_7	0.7159	3.93	0.0002	

picknpay				0.2571
β_0	0.0165	2.07	0.0402	
β_4	0.2505	2.14	0.0341	
β_7	0.8072	6.20	0.0001	
pioneer				0.1465
β_0	0.001	0.14	0.8853	
β_4	0.2396	2.31	0.0224	
β_7	0.4772	4.13	0.0001	
powertech				0.1212
β_0	0.004	0.35	0.7297	
β_4	0.1098	0.66	0.5132	
β_7	0.7935	4.25	0.0001	
ppc				0.0861
β_0	0.0088	1.15	0.2512	
β_4	-0.0015	-0.01	0.9891	
β_7	0.4694	3.75	0.0003	
premier				0.0912
β_0	0.0064	0.64	0.5208	
β_4	0.3795	2.59	0.0109	
β_7	0.4810	2.94	0.0038	
rembrandt				0.3492
β_0	0.0313	4.27	0.0001	
β_4	0.2170	2.44	0.0162	
β_7	0.9205	7.69	0.0001	
barlows				0.4696
β_0	0.0084	1.50	0.1376	
β_4	0.2219	2.69	0.0082	
β_7	0.9226	10.04	0.0001	
blue-circle				0.1277
β_0	0.0080	0.87	0.3887	
β_4	0.2574	1.90	0.0598	
β_7	0.6214	4.12	0.0001	
clicks				0.1472
β_0	0.0149	1.54	0.1263	
β_4	0.3489	2.46	0.0155	
β_7	0.6456	4.08	0.0001	
sabrews				0.3792
β_0	0.0139	2.34	0.0211	
β_4	0.1697	1.94	0.0542	
β_7	0.8268	8.50	0.0001	
amic				0.3498
β_0	0.0097	1.28	0.2042	
β_4	0.2984	2.68	0.0083	
β_7	0.953	7.69	0.0001	
sanland				0.0679
β_0	-0.0054	-0.81	0.4215	
β_4	0.0609	0.62	0.5352	
β_7	0.355	3.25	0.0015	
sappi				0.2140
β_0	0.0132	1.43	0.1542	
β_4	0.2069	1.54	0.1269	
β_7	0.8695	5.80	0.0001	

sasol				0.4110
β_0	0.0041	0.69	0.4926	
β_4	0.2943	3.36	0.0010	
β_7	0.8235	8.44	0.0001	
seardel				0.0772
β_0	0.0078	0.68	0.4997	
β_4	-0.1678	-0.99	0.3235	
β_7	0.6773	3.59	0.0005	
avi				0.1581
β_0	0.017	2.15	0.0339	
β_4	0.2753	2.37	0.0195	
β_7	0.5766	4.45	0.0001	
aeci				0.2844
β_0	0.0022	0.33	0.7412	
β_4	0.0542	0.55	0.5868	
β_7	0.7882	7.11	0.0001	
afcol				0.1544
β_0	0.0063	0.70	0.4880	
β_4	0.2590	1.96	0.0527	
β_7	0.6835	4.63	0.0001	
afrox				0.1942
β_0	0.0104	1.27	0.2084	
β_4	0.1766	1.46	0.1475	
β_7	0.7247	5.37	0.0001	
amaprop				0.0135
β_0	0.0253	1.18	0.2416	
β_4	0.2801	0.89	0.3756	
β_7	0.6383	1.82	0.0721	
ang-alpha				0.1167
β_0	0.0099	1.37	0.1720	
β_4	0.0338	0.32	0.7495	
β_7	0.5209	4.43	0.0001	
tiger-oats				0.2817
β_0	0.0187	2.94	0.0040	
β_4	0.2599	2.79	0.0062	
β_7	0.6547	6.29	0.0001	
tongaat				0.3161
β_0	0.0027	0.41	0.6827	
β_4	0.1794	1.87	0.0644	
β_7	0.7792	7.46	0.0001	
dorbyl				0.2635
β_0	0.0069	0.86	0.3917	
β_4	0.2264	1.94	0.0554	
β_7	0.8375	6.42	0.0001	
hiveld				0.1580
β_0	0.0080	0.83	0.4107	
β_4	0.3216	2.26	0.0254	
β_7	0.6948	4.39	0.0001	
fedfund				0.2062
β_0	0.0002	0.03	0.9758	
β_4	0.3355	3.18	0.0019	
β_7	0.5555	4.72	0.0001	

gf-props				0.2551
β_0	0.0031	0.39	0.6970	
β_4	0.4819	4.11	0.0001	
β_7	0.6597	5.05	0.0001	
santam				0.1288
β_0	0.0065	0.73	0.4681	
β_4	0.1894	1.44	0.1529	
β_7	0.6139	4.18	0.0001	
sbic				0.2188
β_0	0.0091	1.20	0.2316	
β_4	0.2149	1.95	0.0541	
β_7	0.6756	5.49	0.0001	
sentrachem				0.1997
β_0	-0.0032	-0.33	0.7434	
β_4	0.3828	2.65	0.0091	
β_7	0.8143	5.06	0.0001	
abercom				0.1184
β_0	-0.0091	-0.85	0.3967	
β_4	0.2615	1.67	0.0967	
β_7	0.7122	4.09	0.0001	
boland				0.0036
β_0	-0.0069	-1.33	0.1872	
β_4	-0.0483	-0.63	0.5281	
β_7	0.1746	2.05	0.0432	
btrdun				0.1697
β_0	0.0049	0.61	0.5446	
β_4	0.0271	0.23	0.8205	
β_7	0.6914	5.20	0.0001	
goldstein				0.0655
β_0	0.0042	0.32	0.7515	
β_4	0.3651	1.89	0.0613	
β_7	0.5847	2.71	0.0074	
metkor				0.1349
β_0	0.0071	0.71	0.4796	
β_4	0.1400	0.91	0.3643	
β_7	0.7407	4.52	0.0001	
nedcor				0.1916
β_0	0.0017	0.23	0.8188	
β_4	0.2393	2.16	0.0325	
β_7	0.6188	5.02	0.0001	
prima				0.0617
β_0	-0.0036	-0.53	0.5990	
β_4	0.1397	1.39	0.1672	
β_7	0.3102	2.77	0.0064	
romatex				0.0751
β_0	-0.0026	-0.34	0.7339	
β_4	0.0802	0.71	0.4762	
β_7	0.4545	3.63	0.0004	
fedfood				0.1130
β_0	0.0017	0.20	0.8395	
β_4	0.1928	1.58	0.1166	
β_7	0.5243	3.86	0.0002	

bankorp				0.1863
β_0	-0.0031	-0.41	0.6834	
β_4	0.2445	2.22	0.0287	
β_7	0.6084	4.94	0.0001	
concor				-0.0031
β_0	-0.0019	-0.15	0.8824	
β_4	0.0144	0.07	0.9408	
β_7	0.3013	1.40	0.1637	
iandj				0.1253
β_0	0.0195	2.28	0.0245	
β_4	0.2229	1.78	0.0776	
β_7	0.5522	3.96	0.0002	
ics				0.1202
β_0	0.0084	0.99	0.3241	
β_4	0.2759	2.21	0.0288	
β_7	0.5081	3.66	0.0004	
kanhym				0.0622
β_0	-0.0066	-0.55	0.5864	
β_4	0.2146	1.20	0.2311	
β_7	0.6191	3.12	0.0022	
lta				0.0478
β_0	-0.0075	-0.70	0.4830	
β_4	0.3115	2.00	0.0477	
β_7	0.3805	2.19	0.0299	
otis				0.0880
β_0	-0.0044	-0.50	0.6181	
β_4	0.1133	0.88	0.3792	
β_7	0.4943	3.45	0.0007	
		Average	adjusted-R^2	0.1705

The SUR model has an average adjusted-R^2 value of 0.1705 compared to 0.1721 for the APT model. Once again the two models produce almost the same average adjusted-R^2 value for this set of factors, so that they appear to be equally useful for forecasting purposes.

7.4.4 Results for the model with foreign exchange risk and residual market risk

Appendix H reports the SUR results for the model including foreign exchange risk and residual market risk (factors 1 and 7). The average adjusted-R^2 value of the SUR model is 0.1809 compared to 0.1801 for the APT model. The two models are thus very similar with no real difference in terms of goodness of fit.

7.4.5 Results for the model with inflation risk and residual market risk

The average adjusted-R^2 value of the SUR model reported in Appendix I (inflation risk and residual market risk) is 0.1777 and 0.178 for the APT model. The adjusted-R^2 values are virtually the same and so both models appear to be equal in terms of explaining the variations in returns.

7.4.6 Results for the model with default premium risk, gold price risk and residual market risk

The results for the model including default premium risk, gold price risk and residual market risk are reported in Appendix J. Both the APT model and the SUR model reported have similar average adjusted-R^2 values. The SUR has an adjusted-R^2 of 0.1690 whilst the APT's is 0.1703. There is thus not much to distinguish between the two models for this set of factors.

7.5 Summary

The one-factor APT models tested on a sample of mining shares resulted in gold price risk (factor 4) having the highest average adjusted-R^2 value of 0.1444 compared to the second highest for growth rate risk (factor 6) of 0.0154. Both of these models had factor risk-premiums (λ's) which were significantly different from zero. When combined with other factors in the two-factor models, neither the gold price risk nor the growth rate risk produced risk-premiums which were significantly different from zero, although their adjusted-R^2 values were much higher. Thus although the two-factor models including factors 4 and 7, and 6 and 7 are superior for modelling purposes, gold price risk appears to be the only priced APT factor.

There were no one-factor models with adjusted-R^2 values that were higher than 0.01 for the APT tests on the industrial share sample. The two-factor model tests produced three models with high adjusted-R^2 values and risk-premiums which were signficantly different from zero. These were the models including: foreign exchange and residual market risk; inflation rate and residual market risk; and gold price and residual market risk. One three-factor model had a high average adjusted-R^2 value and risk-premiums which were significantly different from zero. It was the model including the default premium risk, gold price risk and the residual market risk.

Each of the 4 models reported for industrial shares had similarly high average adjusted-R^2 values. They are thus equally useful for modelling purposes.

Seemingly unrelated regression models were performed for each of the models selected under the APT tests. All of the average adjusted-R^2 values are virtually the same as for the APT tests, indicating that the APT models and seemingly unrelated regression models are equally useful for modelling purposes. These results are similar to the results obtained by McElroy and Burmeister (1988).

CHAPTER 8: SUMMARY AND INTERPRETATION OF RESULTS

"A rather embarrassing gap exists between the theoretically exclusive importance of systematic 'state variables' and our complete ignorance of their identity" (Chen et al, 1986, 384). The seminal paper by Chen et al introduced the approach of testing a pre-specified factor structure to determine if those factors are priced by the market. Whilst empirical research has suggested a set of factors for the US stock market, the factors affecting shares on the JSE are not necessarily the same. Preliminary South African research on the APT has been undertaken by Page (1986) to determine the number of factors and by Barr (1990) to identify the factors.

This study has used the approach of pre-specifying a set of factors testing those factors under the APT framework. The statistical method applied by McElroy and Burmeister (1988) was adopted. The APT tests were performed separately against mining and industrial share samples for each combination of the selected factors. Seemingly unrelated regression tests were also performed as a comparison to the APT tests.

8.1 Review of adjusted-R^2 values for the APT tests

In each of the four reported models for the APT tests on the industrial sector, the adjusted-R^2 values are consistent with a priori expectations. In general, well-diversified large companies or conglomerates tend to have higher adjusted-R^2 values in accordance with the fact that they are 'more similar to the market' than specialized firms. In particular, these shares are Rembrandt,

Barlows, SA Breweries, Anglo-American Industrial Corporation and Sasol. Because these companies are so well-diversified, a significant proportion of their unsystematic risk is eliminated so that a higher percentage of total risk is composed of systematic risk. Smaller and more specialized companies were typified by lower adjusted-R^2 values. These included Concor (building and construction), Romatex (textiles), LTA (building and construction), Amaprop (Property) and Boland (banking). A review of the individual share betas reveals that these share returns were generally most sensitive to the residual market factor (7) as evidenced by the higher estimates obtained for the factor 7 beta. This could perhaps be explained by data measurement problems.
The average adjusted-R^2 values are fairly low for each of the models because the adjusted-R^2 measures the portion of the total variation of a share's returns which is explained by the model. Because the APT tests are performed on individual shares and not portfolios, the returns will include the effects of unsystematic risk, which can only be eliminated by portfolio diversification. Unsystematic risk typically constitutes a considerable percentage of a share's total risk and so the adjusted-R^2 would be expected to be lower for an individual share than for a diversified portfolio.

8.2 Signs of the risk prices

8.2.1 Industrial shares

Chen, Roll and Ross (1986) report the following signs for the risk-premiums:

1. Inflation risk - negative risk-premium;
2. Growth rate risk - positive risk-premium;
3. Default premium risk - positive risk-premium.

These signs are reasonable given the nature of the factors. For example, the negative premium for inflation risk can be explained as follows. An unexpected increase in inflation will lead to a decrease in observed share returns for those shares with positive betas, and an increase in share returns for shares with negative betas. Appendix D indicates that the risk-premium for inflation risk is negative for the two-factor model reported (factors 3 and 7) in this study.

Chen et al (1986, 395) believe that the positive sign on the growth rate risk "reflects the value of insuring against real systematic production risks". Similarly, the default risk premium is positive because investors want to "hedge against unanticipated increases in the aggregate risk premium occasioned by an increase in uncertainty" (Chen et al, 1986, 395). The results for the one-factor models for mining and industrial shares in this study reported in Table 7.1 and Table 7.6 both have positive signs for the growth rate risk premiums (factor 6). Whilst industrial shares have a positive risk-premium for default risk (factor 2), the mining shares have a negative risk-premium for this factor.

Whilst the risk-premiums for gold price risk have not been estimated in previous studies, the negative risk-premiums for industrial shares for the gold price risk (factor 4) and the foreign exchange rate risks (factor 1) are similarly reasonable (reported in Table 7.7 for the model with gold price and residual market risk, and in Table 7.9 for factors 2 (default premium risk), 4 (gold price risk) and 7 (residual market risk)). A possible explanation is that an unexpected increase in the gold price would cause industrial shares to be less attractive to an investor. Lower demand would cause industrial share prices to fall in the short-term, resulting in a decrease in observed returns. Similarly, a deterioration in the Rand/US dollar exchange rate would cause the cost of imports to increase and a consequent decrease in profits and also share returns for those shares with positive betas.

8.2.2 Mining shares

The signs of the risk-premiums for the gold price factor are different for industrial and mining shares. Whereas the gold price risk-premium is negative for industrial shares, it is positive for the mining shares. Unexpected increases in the gold price should make mining shares more attractive to investors, increasing demand and hence share prices.

8.3 Comparison with other South African studies

Page (1986) identified two priced factors in his factor analysis tests. One was mostly significant in the mining sector and the other predominated the industrial sector. This study is consistent with those results in that the number of priced factors appears to be low - no more than two on each sector. Whilst the mining shares are most affected by the gold price risk, the model containing the gold price and residual market risks appears to be superior in terms of explanatory power (as measured by the average adjusted-R^2 value).

In the industrial sector, the results are less easily determined. The three models reported, each with two factors appear to be equally successful. In addition, one three-factor model was reported.

Whilst it is not possible to clearly identify one industrial share model that is undeniably superior to the others, these models all appear to be plausible. In terms of the JSE as a whole, two or three factors appear to be priced. This result is consistent with Page's study.

8.4 Significance of the residual market risk factor

In both the mining and industrial sectors, the models with the highest average adjusted-R^2 values include the residual market risk factor. Residual market risk includes all systematic risk factors present in the market index, which have not been specified in the model. The significance of the residual market factor indicates that there are risk factors that have not been separately included in the model.

Further work needs to be undertaken to identify these possible factors. For example they could be observable (such as other macroeconomic factors which have not been specified a priori) or unobservable and unquantifiable (such as market confidence). The tests do not provide any clues as to the nature of these components.

8.5 Chosen factor models

The risk-premiums for the separate tests on gold price risk and residual market risk were both significantly different from zero for the mining share sample, indicating that they are priced APT factors. The model including both gold price risk and residual market risk had higher adjusted-R^2 values indicating that this model explains more of the variation in share returns. However, the risk-premiums of this two-factor model were not significantly different from zero so that they are not 'priced' possibly due to multicollinearities between the two factors.

Four models were presented for industrial shares: all with high adjusted-R^2 values and risk-premiums which are significantly different from zero at the 1% level. These were two-factor models with factors 4 and 7 (gold price risk and residual market risk), factors 1 and 7 (foreign exchange risk and residual market risk) and factors 3 and 7 (inflation risk and residual market risk) as well as the three-factor model with factors 2,4 and 7 (default premium risk, gold price risk and residual market risk). Since the models have similar adjusted-R^2 values one model cannot be chosen as better than the others.

The seemingly unrelated regression models produced adjusted-R^2 values which were very similar to the APT model. This appears to indicate that the APT model does not predict share returns better or worse than the SUR model.

8.6 Directions for further work

The importance of the residual market risk factor has been noted. This indicates that there are other factors, observable or unobservable which have not been included in the factor structure tested in this study. Further work can be undertaken to identify other macroeconomic factors that were included in the residual market risk in this study.

More sophisticated measurements for the factors should be developed to ensure one is measuring the unanticipated movement in the variable. For example, McElroy and Burmeister (1988) have used Kalman filtering techniques to estimate the unanticipated inflation risk factor.

The stationarity of the factor structure over time has been assumed in this study. However, like the CAPM beta's, the APT factor betas are unlikely to be constant as was shown by Chen et al (1986). Tests that allow for the non-stationarity of the factor betas can be undertaken.

Finally, the JSE is characterised by low trading and illiquidity. This study overcame the problem of thin-trading by selecting well-traded shares. However, the APT could perhaps be adjusted to take account of thinly-traded markets.

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APPENDIX A

MINING SHARES: APT RESULTS FOR GROWTH RATE RISK (FACTOR 6)

The equation is:

$$r_{it} = R_{ft} + b_{i6}\lambda_6 + b_{i6}f_{6t} + \epsilon_{it}$$

which was regressed using the APT model to obtain the following estimates for expected returns:

$$E(R_{it}) = R_{ft} + b_{i6}\ 0.05564$$

share	b estimate	t-value	prob>|T|	adjusted-R^2
kinross	0.291095	1.53	0.1289	0.0154
kloof	0.234205	1.61	0.11	0.0136
minorco	0.212133	1.24	0.2168	-0.0034
palamin	0.099641	0.89	0.1117	0.0083
randfontein	0.208899	1.26	0.1656	0.0109
rusplat	0.414489	2.46	0.1686	0.0369
southvaal	0.227029	1.47	0.1547	0.0080
amcoal	0.121387	0.95	0.3423	0.0081
samancor	0.126115	0.81	0.4212	0.0002
anglo	0.251782	1.95	0.0537	0.0212
implats	0.391973	2.21	0.0289	0.0266
trans-natal	0.067516	0.54	0.5868	0.0009
debeers	0.304855	2.27	0.0248	0.0390
dries	0.160984	1.29	0.2012	0.0107
et-cons	0.325384	1.93	0.0555	0.0122
ergo	0.234025	1.32	0.1899	0.0138
harties	0.337302	2.14	0.0345	0.0324
genbel	0.293834	1.88	0.0630	0.0199
gencor	0.209477	1.66	0.0939	0.0165
goldfields SA	0.315229	1.82	0.0711	0.0176

APPENDIX B

MINING SHARES: APT RESULTS FOR GROWTH RATE RISK AND RESIDUAL MARKET RISK (FACTORS 6 AND 7)

The equation is:

$$r_{it} = R_{ft} + b_{i6}\lambda_6 + b_{i6}f_{6t} + b_{i7}\lambda_7 + b_{i7}f_{7t} + \epsilon_{it}$$

which was regressed using the APT model to obtain the following estimates for expected returns:

$$E(r_{it}) = R_{ft} + b_{i6}\ 0.02548 + b_{i7}\ 0.00828$$

share	b estimate	t-value	prob > |T|	adjusted-R^2
kinross				0.5966
b6	0.257071	1.86	0.0652	
b7	1.603529	13.12	0.0001	
kloof				0.5551
b6	0.213161	1.93	0.0557	
b7	1.178517	12.08	0.0001	
minorco				0.3172
b6	0.146362	0.91	0.3658	
b7	1.082855	7.59	0.0001	
palamin				0.3004
b6	0.094087	0.87	0.3869	
b7	0.680762	7.10	0.0001	
randfontein				0.5924
b6	0.176364	1.45	0.1500	
b7	1.403464	13.04	0.0001	
rusplat				0.5687
b6	0.388910	3.20	0.0018	
b7	1.317600	12.26	0.0001	
southvaal				0.5229
b6	0.188093	1.54	0.1255	
b7	1.228179	11.39	0.0001	
amcoal				0.1643
b6	0.129172	0.96	0.3395	
b7	0.573271	4.81	0.0001	
samancor				0.1419
b6	0.077523	0.46	0.6442	
b7	0.678340	4.58	0.0001	
anglo				0.7849
b6	0.226896	3.37	0.0010	
b7	1.225817	20.56	0.0001	
implats				0.5461
b6	0.365124	2.76	0.0068	
b7	1.381025	11.79	0.0001	
trans-natal				0.1571
b6	0.116580	0.88	0.3796	
b7	0.553070	4.73	0.0001	
debeers				0.5888
b6	0.319841	3.34	0.0011	
b7	1.069188	12.63	0.0001	
dries				0.5358
b6	0.152437	1.55	0.1228	
b7	1.007537	11.61	0.0001	

et-cons				0.5304
b6	0.272766	2.12	0.0365	
b7	1.321978	11.59	0.0001	
ergo				0.4265
b6	0.250420	1.62	0.1076	
b7	1.266420	9.27	0.0001	
harties				0.6429
b6	0.349560	3.32	0.0012	
b7	1.329453	14.27	0.0001	
genbel				0.5720
b6	0.278961	2.42	0.0171	
b7	1.270145	12.45	0.0001	
gencor				0.6731
b6	0.196697	2.40	0.0178	
b7	1.119343	15.46	0.0001	
goldfields SA				0.5896
b6	0.291014	2.33	0.0217	
b7	1.431409	12.94	0.0001	

APPENDIX C

INDUSTRIAL SHARES: APT RESULTS FOR FOREIGN EXCHANGE RISK AND RESIDUAL MARKET RISK (FACTORS 1 AND 7)

The equation is:

$$r_{it} = R_{ft} + b_{i1}\lambda_1 + b_{i1}f_{1t} + b_{i7}\lambda_7 + b_{i7}f_{7t} + \epsilon_{it}$$

which was regressed using the APT model to obtain the following estimates for expected returns:

$$E(r_{it}) = R_{ft} + b_{i1} -0.0187 + b_{i7}\ 0.02273$$

Share	b estimate	t-value	prob > |T|	Adjusted R^2
liberty				0.2788
b1	-0.00006	-0.00	0.9996	
b7	0.648345	6.96	0.0001	
malbak				0.2310
b1	0.335292	1.99	0.0484	
b7	0.777749	5.96	0.0001	
mccarthy				0.0936
b1	0.331654	1.65	0.1020	
b7	0.578380	3.70	0.0003	
nampak				0.2526
b1	0.412928	3.57	0.0005	
b7	0.514723	5.73	0.0001	
ok				0.2184
b1	0.419250	3.16	0.0020	
b7	0.553298	5.36	0.0001	
pepkor				0.0920
b1	0.248490	1.26	0.2086	
b7	0.596502	3.91	0.0002	
picknpay				0.2637
b1	0.286146	2.05	0.0428	
b7	0.724491	6.67	0.0001	
pioneer				0.1546
b1	0.205585	1.67	0.0983	
b7	0.442087	4.61	0.0001	
powertech				0.1172
b1	-0.03694	-0.18	0.8543	
b7	0.635971	4.08	0.0001	
ppc				0.0979
b1	0.330047	2.47	0.0150	
b7	0.351168	3.38	0.0010	
premier				0.1395
b1	0.439339	2.57	0.0114	
b7	0.549326	4.13	0.0001	
rembrandt				0.3476
b1	-0.0727	-0.56	0.5764	
b7	0.880632	8.74	0.0001	
barlows				0.4570
b1	0.272111	2.70	0.0081	
b7	0.775651	9.90	0.0001	
blue-circle				0.1529
b1	0.182969	1.14	0.2546	
b7	0.603026	4.86	0.0001	

clicks				0.1752
b1	0.366565	2.19	0.0305	
b7	0.651335	5.01	0.0001	
sa-brews				0.3740
b1	0.200903	1.90	0.0597	
b7	0.713510	8.70	0.0001	
amic				0.3561
b1	0.299737	2.25	0.0264	
b7	0.834786	8.06	0.0001	
sanland				0.0639
b1	-0.09086	-0.77	0.4402	
b7	0.274203	3.01	0.0032	
sappi				0.2351
b1	0.282700	1.77	0.0786	
b7	0.774881	6.26	0.0001	
sasol				0.3800
b1	0.176424	1.63	0.1056	
b7	0.703207	8.37	0.0001	
seardel				0.0473
b1	0.086182	0.42	0.6757	
b7	0.489486	3.03	0.0027	
avi				0.1848
b1	0.199602	1.46	0.1481	
b7	0.601194	5.64	0.0001	
aeci				0.2542
b1	0.324992	2.66	0.0088	
b7	0.588021	6.20	0.0001	
afcol				0.1994
b1	0.403329	2.61	0.0102	
b7	0.633781	5.28	0.0001	
afrox				0.1957
b1	0.184296	1.27	0.2064	
b7	0.625328	5.55	0.0001	
amaprop				0.0280
b1	0.116534	0.31	0.7756	
b7	0.718885	2.48	0.0147	
anglo-alpha				0.1372
b1	0.323437	2.59	0.0109	
b7	0.422828	4.35	0.0001	
tiger-oats				0.2785
b1	0.196972	1.75	0.0823	
b7	0.623993	7.15	0.0001	
tongaat				0.3176
b1	0.267958	2.32	0.0220	
b7	0.667378	7.44	0.0001	
dorbyl				0.2666
b1	0.292873	2.09	0.0389	
b7	0.711112	6.53	0.0001	
hiveld				0.2107
b1	-0.22935	-1.39	0.1675	
b7	0.692283	5.40	0.0001	
fedfund				0.1987
b1	0.157185	1.24	0.2191	
b7	0.536052	5.42	0.0001	
gf-props				0.3324
b1	0.666761	4.97	0.0001	
b7	0.653285	6.27	0.0001	
santam				0.1338
b1	0.094638	0.62	0.5480	
b7	0.541185	4.43	0.0001	

sbic				0.2156
b1	0.281572	2.12	0.0360	
b7	0.570373	5.53	0.0001	
sentrachem				0.2077
b1	0.332217	1.93	0.0562	
b7	0.750232	5.61	0.0001	
abercom				0.1524
b1	0.560428	3.05	0.0028	
b7	0.604421	4.24	0.0001	
boland				-0.0239
b1	0.070694	0.76	0.4459	
b7	0.090400	1.26	0.2109	
btr-dunlop				0.1442
b1	0.197484	1.36	0.1759	
b7	0.519641	4.61	0.0001	
goldstein				0.0819
b1	0.114234	0.50	0.6188	
b7	0.622366	3.50	0.0007	
metkor				0.1368
b1	0.207899	1.18	0.2396	
b7	0.616266	4.51	0.0001	
nedcor				0.1880
b1	0.158204	1.19	0.2359	
b7	0.542966	5.26	0.0001	
prima				0.0593
b1	0.147933	1.23	0.2214	
b7	0.261817	2.80	0.0060	
romatex				0.0950
b1	0.290434	2.17	0.0309	
b7	0.362555	3.51	0.0006	
fedfood				0.1227
b1	0.231809	1.60	0.1130	
b7	0.456720	4.05	0.0001	
bankorp				0.1752
b1	0.193969	1.46	0.1479	
b7	0.525451	5.08	0.0001	
concor				0.0018
b1	0.072114	0.31	0.7551	
b7	0.224563	1.25	0.2128	
i&j				0.1337
b1	0.000822	0.01	0.9956	
b7	0.560054	4.83	0.0001	
ics				0.1481
b1	0.327442	2.23	0.0277	
b7	0.496941	4.35	0.0001	
kanhym				0.0928
b1	0.500479	2.38	0.0187	
b7	0.531368	3.26	0.0015	
lta				0.0996
b1	0.580311	3.20	0.0018	
b7	0.375534	2.66	0.0088	
otis				0.0687
b1	0.110754	0.71	0.4765	
b7	0.366685	3.04	0.0029	

APPENDIX D

INDUSTRIAL SHARES: APT RESULTS FOR INFLATION RISK AND RESIDUAL MARKET RISK (FACTORS 3 AND 7)

The equation is:

$$r_{it} = R_{ft} + b_{i3}\lambda_3 + b_{i3}f_{3t} + b_{i7}\lambda_7 + b_{i7}f_{7t} + \epsilon_{it}$$

which was regressed using the APT model to obtain the following estimates for expected returns:

$$E(r_{it}) = R_{ft} + b_{i3}\ -0.4674 + b_{i7}\ 0.02216$$

share	b estimate	t-value	prob>|T|	Adjusted R^2
liberty				0.2679
b3	0.003398	0.32	0.7516	
b7	0.634904	6.75	0.0001	
malbak				0.2324
b3	0.020957	1.41	0.1601	
b7	0.803906	6.15	0.0001	
mccarthy				0.0948
b3	0.023721	1.36	0.1767	
b7	0.610902	3.90	0.0002	
nampak				0.2155
b3	0.011322	1.09	0.2782	
b7	0.542999	5.90	0.0001	
ok				0.2247
b3	0.031759	2.70	0.0081	
b7	0.602316	5.85	0.0001	
pepkor				0.0902
b3	0.001327	0.08	0.9380	
b7	0.599975	3.91	0.0002	
picknpay				0.2631
b3	-0.00058	-0.05	0.9624	
b7	0.726305	6.68	0.0001	
pioneer				0.1622
b3	0.017717	1.65	0.1020	
b7	0.463910	4.84	0.0001	
powertech				0.1106
b3	0.007579	0.43	0.6646	
b7	0.625521	3.98	0.0001	
ppc				0.0846
b3	-0.01048	-0.90	0.3707	
b7	0.356235	3.39	0.0009	
premier				0.1197
b3	0.015134	1.01	0.3153	
b7	0.582933	4.33	0.0001	
rembrandt				0.3540
b3	-0.01896	-1.60	0.1120	
b7	0.833198	8.31	0.0001	
barlows				0.4599
b3	0.016573	1.78	0.0781	
b7	0.792662	10.15	0.0001	
blue-circle				0.1571
b3	0.016737	1.20	0.2319	
b7	0.617797	4.97	0.0001	

clicks				0.1646
b3	0.005505	0.37	0.7085	
b7	0.666813	5.08	0.0001	
sa-brews				0.3755
b3	0.012847	1.34	0.1828	
b7	0.722445	8.81	0.0001	
amic				0.3595
b3	0.019783	1.65	0.1024	
b7	0.855399	8.28	0.0001	
sanland				0.0552
b3	0.010808	1.06	0.2897	
b7	0.272348	2.96	0.0037	
sappi				0.2336
b3	0.006501	0.46	0.6648	
b7	0.782629	6.30	0.0001	
sasol				0.3985
b3	0.021096	2.16	0.0327	
b7	0.719649	8.65	0.0001	
seardel				0.0588
b3	-0.01560	-0.88	0.3788	
b7	0.468981	2.94	0.0039	
avi				0.1958
b3	-0.00893	-0.74	0.4581	
b7	0.591641	5.58	0.0001	
aeci				0.2494
b3	0.017729	1.63	0.1047	
b7	0.615029	6.46	0.0001	
afcol				0.2009
b3	0.028443	2.09	0.0391	
b7	0.675346	5.62	0.0001	
afrox				0.1985
b3	-0.00112	-0.09	0.9301	
b7	0.622246	5.52	0.0001	
amaprop				0.0280
b3	0.015450	0.48	0.6311	
b7	0.722777	2.48	0.0146	
anglo-alpha				0.1173
b3	0.011660	1.06	0.2910	
b7	0.446735	4.54	0.0001	
tiger-oats				0.2815
b3	-0.00175	-0.18	0.8612	
b7	0.620132	7.11	0.0001	
tongaat				0.3245
b3	0.019711	1.91	0.0590	
b7	0.690363	7.73	0.0001	
dorbyl				0.2643
b3	0.003404	0.27	0.7846	
b7	0.718839	6.58	0.0001	
hiveld				0.1712
b3	0.004221	0.29	0.7749	
b7	0.662912	5.04	0.0001	
fedfund				0.2093
b3	0.018338	1.65	0.1020	
b7	0.552926	5.61	0.0001	
gf-props				0.2628
b3	0.023458	1.88	0.0620	
b7	0.709359	6.50	0.0001	
santam				0.1338
b3	0.005526	0.41	0.6861	
b7	0.540277	4.41	0.0001	

sbic				0.2189
b3	0.020540	1.76	0.0814	
b7	0.596283	5.78	0.0001	
sentrachem				0.2089
b3	0.019236	1.27	0.2062	
b7	0.776547	5.79	0.0001	
abercom				0.1487
b3	0.038892	2.40	0.0179	
b7	0.670192	4.67	0.0001	
boland				-0.0250
b3	0.003220	0.41	0.6850	
b7	0.097544	1.35	0.1793	
btr-dunlop				0.1595
b3	0.024244	1.92	0.0570	
b7	0.544648	4.86	0.0001	
goldstein				0.0975
b3	-0.02052	-1.04	0.2999	
b7	0.596946	3.37	0.0010	
metkor				0.1366
b3	0.006368	0.42	0.6778	
b7	0.622696	4.54	0.0001	
nedcor				0.2150
b3	0.027738	2.39	0.0182	
b7	0.568399	5.58	0.0001	
prima				0.0597
b3	0.009448	0.91	0.3640	
b7	0.276220	2.94	0.0039	
romatex				0.0872
b3	0.016072	1.39	0.1676	
b7	0.391354	3.76	0.0003	
fedfood				0.1390
b3	0.025485	2.02	0.0453	
b7	0.487380	4.34	0.0001	
bankorp				0.1765
b3	0.009845	0.85	0.3988	
b7	0.537616	5.18	0.0001	
concor				0.0029
b3	-0.00427	-0.22	0.8290	
b7	0.221020	1.23	0.2218	
i&j				0.1272
b3	0.001945	0.15	0.8816	
b7	0.546723	4.68	0.0001	
ics				0.1345
b3	0.003401	0.26	0.7917	
b7	0.511883	4.44	0.0001	
kanhym				0.0959
b3	0.038657	2.12	0.0365	
b7	0.593845	3.63	0.0004	
lta				0.0822
b3	0.038441	2.41	0.0177	
b7	0.447275	3.14	0.0022	
otis				0.0775
b3	0.017203	1.29	0.2000	
b7	0.383339	3.18	0.0019	

APPENDIX E

INDUSTRIAL SHARES: APT TEST RESULTS FOR DEFAULT PREMIUM RISK, GOLD PRICE RISK AND THE RESIDUAL MARKET RISK (FACTORS 2,4 AND 7)

The equation is:

$$r_{it} = R_{ft} + b_{i2}\lambda_2 + b_{i2}f_{2t} + b_{i4}\lambda_{4t} + b_{i4}f_{4t} + b_{i7}\lambda_7 + b_{i7}f_{7t} + \epsilon_{it}$$

which was regressed using the APT model to obtain the following estimates for expected returns:

$$E(r_{it}) = R_{ft} + b_{i2}\ -0.3759 + b_{i4}\ -0.094 + b_{i7}\ 0.0527$$

share	b estimate	t-value	prob > |T|	adjusted-R^2
liberty				0.2761
b2	0.015046	0.92	0.3612	
b4	0.205826	2.63	0.0098	
b7	0.722409	6.96	0.0001	
malbak				0.2029
b2	0.013918	0.60	0.5523	
b4	0.360430	3.25	0.0015	
b7	0.820362	5.55	0.0001	
mccarthy				0.0852
b2	0.027940	1.02	0.3113	
b4	0.102749	0.80	0.4266	
b7	0.665034	3.82	0.0002	
nampak				0.2032
b2	0.008487	0.52	0.6018	
b4	0.205009	2.67	0.0087	
b7	0.586499	5.71	0.0001	
ok				0.1882
b2	0.000097	0.01	0.9958	
b4	0.336146	3.80	0.0002	
b7	0.594925	5.09	0.0001	
pepkor				0.1132
b2	0.043170	1.63	0.1059	
b4	0.042885	0.34	0.7324	
b7	0.716660	4.27	0.0001	
picknpay				0.2762
b2	-0.02736	-1.44	0.1530	
b4	0.325960	3.56	0.0005	
b7	0.770650	6.42	0.0001	
pioneer				0.1567
b2	0.023519	1.40	0.1645	
b4	0.196482	2.47	0.0150	
b7	0.497332	4.67	0.0001	
powertech				0.1135
b2	0.020737	0.76	0.4496	
b4	0.218256	1.70	0.0912	
b7	0.721260	4.16	0.0001	
ppc				0.0780
b2	0.003842	0.21	0.8345	
b4	0.080030	0.93	0.3535	
b7	0.418538	3.60	0.0005	

premier				0.0926
b2	-0.02075	-0.87	0.3874	
b4	0.332424	2.95	0.0039	
b7	0.517738	3.42	0.0009	
rembrandt				0.3514
b2	-0.00974	-0.55	0.5851	
b4	0.243151	2.80	0.0060	
b7	0.937058	8.35	0.0001	
barlows				0.4637
b2	0.020330	1.47	0.1443	
b4	0.285603	4.19	0.0001	
b7	0.878472	10.09	0.0001	
blue-circle				0.1272
b2	0.004362	0.20	0.8436	
b4	0.251322	2.42	0.0170	
b7	0.624987	4.47	0.0001	
clicks				0.1522
b2	-0.02209	-0.95	0.3417	
b4	0.322164	2.94	0.0039	
b7	0.670382	4.58	0.0001	
sa-brews				0.3771
b2	0.016883	1.17	0.2454	
b4	0.209396	2.99	0.0035	
b7	0.798419	8.75	0.0001	
amic				0.3482
b2	0.014916	0.81	0.4186	
b4	0.335783	3.79	0.0002	
b7	0.926945	7.99	0.0001	
sanland				0.0556
b2	0.010669	0.67	0.5065	
b4	0.140116	1.87	0.0640	
b7	0.303203	2.99	0.0034	
sappi				0.2226
b2	0.034315	1.57	0.1201	
b4	0.204959	1.97	0.0515	
b7	0.861412	6.21	0.0001	
sasol				0.4278
b2	0.033925	2.36	0.0200	
b4	0.284310	4.02	0.0001	
b7	0.820459	9.06	0.0001	
scardel				0.0509
b2	0.015576	0.56	0.5755	
b4	0.042220	0.32	0.7468	
b7	0.543540	3.07	0.0026	
avi				0.1615
b2	-0.01721	-0.91	0.3659	
b4	0.244249	2.72	0.0076	
b7	0.602358	5.02	0.0001	
aeci				0.2721
b2	0.036483	2.21	0.0289	
b4	0.164739	2.08	0.0393	
b7	0.709601	6.81	0.0001	
afcol				0.1544
b2	0.011678	0.54	0.5895	
b4	0.263683	2.59	0.0108	
b7	0.678183	4.96	0.0001	
afrox				0.2133
b2	0.039591	2.02	0.0457	
b4	0.151217	1.62	0.1076	
b7	0.729278	5.88	0.0001	

amaprop				0.0123
b2	0.023983	0.47	0.6395	
b4	0.126631	0.53	0.5951	
b7	0.726979	2.24	0.0268	
anglo-alpha				0.1147
b2	0.017118	0.99	0.3222	
b4	0.076497	0.94	0.3470	
b7	0.490019	4.49	0.0001	
tiger-oats				0.2781
b2	0.011086	0.72	0.4720	
b4	0.187398	2.55	0.0121	
b7	0.697325	7.18	0.0001	
tongaat				0.3080
b2	0.022291	1.40	0.1639	
b4	0.256551	3.35	0.0011	
b7	0.745815	7.42	0.0001	
dorbyl				0.2582
b2	0.005294	0.27	0.7839	
b4	0.304752	3.32	0.0012	
b7	0.788900	6.48	0.0001	
hiveld				0.1803
b2	0.045985	2.01	0.0472	
b4	0.210551	1.94	0.0552	
b7	0.750300	5.17	0.0001	
fedfund				0.2062
b2	-0.00200	-0.12	0.9084	
b4	0.326536	3.93	0.0001	
b7	0.562767	5.13	0.0001	
gf-props				0.2520
b2	-0.00884	-0.46	0.6495	
b4	0.425768	4.53	0.0001	
b7	0.698490	5.70	0.0001	
santam				0.1320
b2	-0.01263	-0.59	0.5565	
b4	0.262919	2.61	0.0103	
b7	0.573566	4.23	0.0001	
sbic				0.2188
b2	0.011393	0.63	0.5293	
b4	0.225535	2.64	0.0095	
b7	0.666709	5.83	0.0001	
sentrachem				0.1986
b2	0.012270	0.52	0.6057	
b4	0.412919	3.65	0.0004	
b7	0.793279	5.29	0.0001	
abercom				0.1292
b2	0.043654	1.72	0.0882	
b4	0.287795	2.39	0.0185	
b7	0.683402	4.25	0.0001	
boland				-0.0138
b2	0.017869	1.43	0.1556	
b4	0.027483	0.47	0.6385	
b7	0.122321	1.54	0.1256	
btr-dunlop				0.1497
b2	0.012007	0.61	0.5427	
b4	0.162827	1.76	0.0810	
b7	0.604876	4.85	0.0001	
goldstein				0.0652
b2	-0.00753	-0.24	0.8110	
b4	0.339392	2.31	0.0229	
b7	0.604189	3.03	0.0030	

metkor				0.1288
b2	0.008425	0.35	0.7265	
b4	0.223898	1.99	0.0495	
b7	0.683734	4.49	0.0001	
nedcor				0.1946
b2	-0.01088	-0.60	0.5485	
b4	0.311009	3.61	0.0005	
b7	0.579016	5.06	0.0001	
prima				0.0652
b2	0.015489	0.95	0.3446	
b4	0.143617	1.88	0.0630	
b7	0.303471	2.93	0.0040	
romatex				0.0634
b2	0.004132	0.23	0.8223	
b4	0.177786	2.07	0.0408	
b7	0.393675	3.38	0.0010	
fedfood				0.1255
b2	-0.02345	-1.18	0.2385	
b4	0.289299	3.09	0.0025	
b7	0.472981	3.77	0.0003	
bankorp				0.1823
b2	0.002352	0.13	0.8970	
b4	0.307746	3.56	0.0005	
b7	0.569625	4.96	0.0001	
concor				-0.0002
b2	-0.02583	-0.82	0.4115	
b4	0.164468	1.13	0.2618	
b7	0.217122	1.09	0.2771	
i&j				0.1208
b2	-0.00002	-0.00	0.9992	
b4	0.160133	1.67	0.0986	
b7	0.592189	4.57	0.0001	
ics				0.1261
b2	-0.01743	-0.86	0.3916	
b4	0.272852	2.85	0.0051	
b7	0.516526	4.02	0.0001	
kanhym				0.0676
b2	0.036353	1.26	0.2114	
b4	0.240765	1.77	0.0788	
b7	0.592565	3.23	0.0016	
lta				0.0503
b2	-0.01277	-0.50	0.6155	
b4	0.330463	2.76	0.0067	
b7	0.373584	2.33	0.0218	
otis				0.0805
b2	-0.00795	-0.38	0.7052	
b4	0.242101	2.46	0.0154	
b7	0.418029	3.14	0.0021	

APPENDIX F

MINING SHARES: SEEMINGLY UNRELATED REGRESSION MODEL FOR GROWTH RATE RISK (FACTOR 6)

share	β_i	t-value	prob > |T|	adjusted-R^2
kinross				0.0080
β_0	0.0187	1.33	0.1852	
β_6	0.0026	1.19	0.2355	
kloof				0.0060
β_0	0.0146	1.37	0.1742	
β_6	0.0021	1.29	0.1984	
minorco				-0.0068
β_0	0.0181	1.43	0.1563	
β_6	0.0013	0.67	0.5017	
palamin				0.0003
β_0	0.0055	0.65	0.5145	
β_6	0.0010	0.77	0.4431	
randfontein				0.0035
β_0	0.0137	1.12	0.2664	
β_6	0.0018	0.95	0.3430	
rusplat				0.0304
β_0	0.0262	2.22	0.0284	
β_6	0.0038	2.05	0.0427	
southvaal				0.0016
β_0	0.0159	1.39	0.1658	
β_6	0.0019	1.05	0.2976	
amcoal				0.0003
β_0	0.0057	0.59	0.5535	
β_6	0.0014	0.91	0.3650	
samancor				-0.0048
β_0	0.0117	1.00	0.3216	
β_6	0.0007	0.37	0.7129	
anglo				0.0141
β_0	0.016	1.72	0.0887	
β_6	0.0023	1.56	0.1207	
implats				0.0197
β_0	0.0247	1.96	0.0519	
β_6	0.0036	1.81	0.0725	
trans-natal				0.0002
β_0	-0.002	-0.22	0.8288	
β_6	0.0014	0.97	0.3353	
debeers				0.0317
β_0	0.0155	1.63	0.1058	
β_6	0.0032	2.19	0.0305	
dries				0.0027
β_0	0.009	0.97	0.3352	
β_6	0.0016	1.11	0.2699	
et-cons				0.0078
β_0	0.0234	1.93	0.0566	
β_6	0.0026	1.37	0.1725	
ergo				0.0065
β_0	0.0105	0.79	0.4284	
β_6	0.0027	1.30	0.1960	
harties				0.0249
β_0	0.0173	1.53	0.1275	
β_6	0.0036	2.03	0.0443	
genbel				0.0121
β_0	0.0175	1.54	0.1253	
β_6	0.0028	1.58	0.1163	

gencor				0.0086
β_0	0.0123	1.33	0.1854	
β_6	0.0020	1.41	0.1623	
goldfields SA				0.0101
β_0	0.0195	1.55	0.1233	
β_6	0.0029	1.48	0.1403	
		Average	adjusted-R^2	0.0089

APPENDIX G

MINING SHARES: SEEMINGLY UNRELATED REGRESSION MODEL FOR GROWTH RATE RISK AND RESIDUAL MARKET RISK (FACTORS 6 AND 7)

Share	β-estimate	t-value	prob > |T|	adjusted-R^2
kinross				0.5936
β_0	0.0187	2.08	0.0395	
β_6	0.0026	1.86	0.0650	
β_7	1.6055	13.02	0.0001	
kloof				0.5517
β_0	0.0146	2.04	0.0440	
β_6	0.0021	1.93	0.0566	
β_7	1.1795	11.98	0.0001	
minorco				0.3139
β_0	0.0181	1.73	0.0866	
β_6	0.0014	0.82	0.4159	
β_7	1.0736	7.46	0.0001	
palamin				0.2959
β_0	0.0055	0.78	0.4375	
β_6	0.0010	0.92	0.3610	
β_7	0.6851	7.08	0.0001	
randfontein				0.5896
β_0	0.0137	1.74	0.0845	
β_6	0.0018	1.48	0.1406	
β_7	1.4075	12.97	0.0001	
rusplat				0.5675
β_0	0.0262	3.32	0.0012	
β_6	0.0038	3.07	0.0027	
β_7	1.3085	12.10	0.0001	
southvaal				0.5193
β_0	0.0159	2.01	0.0468	
β_6	0.0019	1.51	0.1343	
β_7	1.2266	11.27	0.0001	
amcoal				0.1585
β_0	0.0057	0.65	0.5185	
β_6	0.0014	0.99	0.3237	
β_7	0.5773	4.79	0.0001	
samancor				0.1365
β_0	0.0117	1.07	0.2852	
β_6	0.0007	0.40	0.6914	
β_7	0.6713	4.49	0.0001	
anglo				0.7832
β_0	0.016	3.66	0.0004	
β_6	0.0023	3.33	0.0011	
β_7	1.2266	20.40	0.0001	
implats				0.5436
β_0	0.0247	2.88	0.0048	
β_6	0.0036	2.66	0.0090	
β_7	1.3742	11.63	0.0001	
trans-natal				0.1616
β_0	-0.002	-0.24	0.8133	
β_6	0.0014	1.06	0.2929	
β_7	0.5694	4.85	0.0001	
debeers				0.5858
β_0	0.0155	2.49	0.0141	
β_6	0.0032	3.35	0.0011	
β_7	1.0718	12.55	0.0001	

dries				0.5335
β_0	0.009	1.41	0.1598	
β_6	0.0016	1.62	0.1077	
β_7	1.0130	11.58	0.0001	
et-cons				0.5288
β_0	0.0234	2.79	0.0061	
β_6	0.0026	1.99	0.0487	
β_7	1.3126	11.42	0.0001	
ergo				0.4245
β_0	0.0105	1.04	0.2986	
β_6	0.0027	1.71	0.0902	
β_7	1.2774	9.27	0.0001	
harties				0.6407
β_0	0.0173	2.53	0.0128	
β_6	0.0036	3.35	0.0011	
β_7	1.3340	14.20	0.0001	
genbel				0.5687
β_0	0.0175	2.34	0.0212	
β_6	0.0028	2.39	0.0182	
β_7	1.2703	12.33	0.0668	
gencor				0.6710
β_0	0.0123	2.31	0.0255	
β_6	0.0020	2.44	0.0161	
β_7	1.1228	15.38	0.0001	
goldfields SA				0.5864
β_0	0.0195	2.40	0.0179	
β_6	0.0029	2.30	0.0234	
β_7	1.4309	12.81	0.0001	
		Average	adjusted-R^2	0.4877

APPENDIX H

INDUSTRIAL SHARES: SEEMINGLY UNRELATED REGRESSION MODEL FOR FOREIGN EXCHANGE RISK AND RESIDUAL MARKET RISK (FACTORS 1 AND 7)

Share	β-estimates	t-value	prob > |T|	adjusted-R^2
liberty				0.2733
β_0	0.0132	1.93	0.0557	
β_1	-0.0102	-0.08	0.9355	
β_7	0.6557	6.74	0.0001	
malbak				0.2292
β_0	0.0043	0.45	0.6517	
β_1	0.2900	1.65	0.1002	
β_7	0.8104	5.95	0.0001	
mccarthy				0.0866
β_0	0.0094	0.82	0.4119	
β_1	0.3477	1.64	0.1036	
β_7	0.5668	3.46	0.0008	
nampak				0.2479
β_0	0.0068	1.04	0.3017	
β_1	0.4310	3.56	0.0005	
β_7	0.5017	5.36	0.0001	
ok				0.2280
β_0	-0.0058	-0.77	0.4404	
β_1	0.3522	2.55	0.0119	
β_7	0.6017	5.64	0.0001	
pepkor				0.0907
β_0	0.0179	1.60	0.1116	
β_1	0.3059	1.48	0.1409	
β_7	0.5551	3.48	0.0007	
picknpay				0.2593
β_0	0.0148	1.87	0.0637	
β_1	0.3099	2.12	0.0365	
β_7	0.7073	6.24	0.0001	
pioneer				0.1559
β_0	-0.0006	-0.08	0.9343	
β_1	0.1623	1.26	0.2116	
β_7	0.4733	4.74	0.0001	
powertech				0.1200
β_0	0.0033	0.29	0.7743	
β_1	-0.1128	-0.54	0.5924	
β_7	0.6908	4.25	0.0001	
ppc				0.0984
β_0	0.0088	1.16	0.2504	
β_1	0.3745	2.67	0.0086	
β_7	0.3191	2.94	0.0039	
premier				0.1324
β_0	0.0039	0.40	0.6918	
β_1	0.4369	2.43	0.0167	
β_7	0.5511	3.96	0.0001	
rembrandt				0.3509
β_0	0.030	4.07	0.0001	
β_1	-0.0203	-0.15	0.8803	
β_7	0.8428	8.10	0.0001	
barlows				0.4581
β_0	0.0069	1.22	0.2248	
β_1	0.2362	2.26	0.0258	
β_7	0.8016	9.91	0.0001	

blue-circle				0.1476
β_0	0.0063	0.69	0.4910	
β_1	0.1574	0.94	0.3508	
β_7	0.6215	4.78	0.0001	
clicks				0.1704
β_0	0.0125	1.32	0.1897	
β_1	0.3960	2.25	0.0262	
β_7	0.6301	4.63	0.0001	
sabrews				0.3688
β_0	0.0128	2.14	0.0347	
β_1	0.2028	1.84	0.0688	
β_7	0.7121	8.34	0.0001	
amic				0.3547
β_0	0.0077	1.02	0.3094	
β_1	0.2635	1.89	0.0607	
β_7	0.8609	8.00	0.0001	
sanland				0.0979
β_0	-0.0057	-0.88	0.3822	
β_1	-0.1782	-1.47	0.1432	
β_7	0.3373	3.61	0.0005	
sappi				0.2288
β_0	0.0117	1.30	0.1968	
β_1	0.2790	1.67	0.0980	
β_7	0.7775	6.01	0.0001	
sasol				0.3943
β_0	0.0022	0.36	0.7196	
β_1	0.1093	0.98	0.3286	
β_7	0.7517	8.72	0.0001	
seardel				0.0395
β_0	0.0089	0.76	0.4500	
β_1	0.0822	0.38	0.7053	
β_7	0.4924	2.94	0.0040	
avi				0.1820
β_0	0.0152	1.95	0.0536	
β_1	0.2331	1.62	0.1078	
β_7	0.5700	5.19	0.0001	
aeci				0.2530
β_0	0.0018	0.26	0.7924	
β_1	0.2901	2.27	0.0248	
β_7	0.6132	6.21	0.0001	
afcol				0.1934
β_0	0.0045	0.51	0.6092	
β_1	0.3883	2.39	0.0183	
β_7	0.6446	5.14	0.0001	
afrox				0.1893
β_0	0.0093	1.12	0.2640	
β_1	0.1747	1.15	0.2544	
β_7	0.6323	5.36	0.0001	
amaprop				0.0219
β_0	0.0234	1.10	0.2737	
β_1	0.1757	0.45	0.6562	
β_7	0.6761	2.22	0.0283	
ang-alpha				0.1366
β_0	0.0095	1.35	0.1788	
β_1	0.3620	2.76	0.0067	
β_7	0.3950	3.90	0.0002	
tiger-oats				0.2804
β_0	0.0169	2.68	0.0085	
β_1	0.2383	2.03	0.0443	
β_7	0.5942	6.55	0.0001	

tongaat				0.3247
β_0	0.0015	0.23	0.8215	
β_1	0.2125	1.77	0.0788	
β_7	0.7074	7.63	0.0001	
dorbyl				0.2641
β_0	0.0053	0.67	0.5039	
β_1	0.2587	1.76	0.0807	
β_7	0.7358	6.48	0.0001	
hiveld				0.2231
β_0	0.006	0.65	0.5192	
β_1	-0.3191	-1.86	0.0650	
β_7	0.7571	5.71	0.0001	
fedfund				0.2126
β_0	-0.0020	-0.28	0.7819	
β_1	0.0855	0.65	0.5187	
β_7	0.5878	5.75	0.0001	
gf-props				0.3277
β_0	-0.0002	-0.02	0.9817	
β_1	0.6506	4.65	0.0001	
β_7	0.6649	6.15	0.0001	
santam				0.1298
β_0	0.0053	0.59	0.5549	
β_1	0.0612	0.37	0.7118	
β_7	0.5654	4.43	0.0001	
sbic				0.2091
β_0	0.0076	1.01	0.3165	
β_1	0.2810	2.01	0.0464	
β_7	0.5708	5.29	0.0001	
sentrachem				0.2254
β_0	-0.006	-0.6	0.5503	
β_1	0.2262	1.27	0.2070	
β_7	0.8268	6.00	0.0001	
abercom				0.1619
β_0	-0.1088	-1.05	0.2949	
β_1	0.4703	2.46	0.0153	
β_7	0.6695	4.53	0.0001	
boland				-0.0114
β_0	-0.0066	-1.26	0.2088	
β_1	0.0239	0.25	0.8052	
β_7	0.1242	1.66	0.0990	
btrdun				0.1386
β_0	0.0047	0.57	0.5681	
β_1	0.1758	1.15	0.2513	
β_7	0.5353	4.54	0.0001	
goldstein				0.0803
β_0	0.0018	0.14	0.8903	
β_1	0.0490	0.20	0.8389	
β_7	0.6695	3.60	0.0005	
metkor				0.1311
β_0	0.0062	0.62	0.5369	
β_1	0.1829	0.99	0.3250	
β_7	0.6343	4.43	0.0001	
nedcor				0.1942
β_0	0.0002	0.02	0.9839	
β_1	0.0993	0.72	0.4752	
β_7	0.5855	5.46	0.0001	
prima				0.0642
β_0	-0.0045	-0.67	0.5059	
β_1	0.0986	0.78	0.4357	
β_7	0.2975	3.05	0.0028	

romatex				0.0936
β_0	-0.0032	-0.42	0.6728	
β_1	0.2522	1.81	0.0733	
β_7	0.3902	3.62	0.0004	
fedfood				0.1198
β_0	0.0004	0.05	0.9627	
β_1	0.1957	1.28	0.2020	
β_7	0.4828	4.09	0.0001	
bankorp				0.1943
β_0	-0.0047	-0.63	0.5303	
β_1	0.1109	0.80	0.4229	
β_7	0.5854	5.49	0.0001	
concor				-0.0044
β_0	-0.0021	-0.16	0.8759	
β_1	0.0349	0.14	0.8859	
β_7	0.2514	1.34	0.1840	
iandj				0.1301
β_0	0.018	2.12	0.0358	
β_1	0.0346	0.22	0.8255	
β_7	0.5356	4.42	0.0001	
ics				0.1413
β_0	0.0065	0.78	0.4357	
β_1	0.3362	2.18	0.0316	
β_7	0.4906	4.10	0.0001	
kanhym				0.0932
β_0	-0.0081	-0.68	0.4955	
β_1	0.4313	1.96	0.0524	
β_7	0.5814	3.42	0.0009	
lta				0.0969
β_0	-0.0096	-0.94	0.3514	
β_1	0.5337	2.81	0.0059	
β_7	0.4091	2.78	0.0063	
otis				0.0774
β_0	-0.0051	-0.58	0.5601	
β_1	0.0380	0.23	0.8149	
β_7	0.4192	3.34	0.0011	
		Average	adjusted-R^2	0.1809

APPENDIX I

INDUSTRIAL SHARES: SEEMINGLY UNRELATED REGRESSION MODEL FOR INFLATION RISK AND RESIDUAL MARKET RISK (FACTORS 3 AND 7)

Share	β-estimates	t-value	prob > |T|	adjusted-R^2
liberty				0.2620
β_0	0.0131	1.91	0.0583	
β_3	0.0046	0.33	0.7398	
β_7	0.6321	6.54	0.0001	
malbak				0.2281
β_0	0.0043	0.45	0.6548	
β_3	0.0141	0.74	0.4614	
β_7	0.8206	6.11	0.0001	
mccarthy				0.0927
β_0	0.0092	0.81	0.4203	
β_3	0.0362	1.59	0.1155	
β_7	0.5806	3.61	0.0005	
nampak				0.2090
β_0	0.0068	1.01	0.3126	
β_3	0.0115	0.85	0.3951	
β_7	0.5427	5.74	0.0001	
ok				0.2228
β_0	-0.0059	-0.78	0.4343	
β_3	0.0237	1.59	0.1154	
β_7	0.6217	5.90	0.0001	
pepkor				0.0860
β_0	0.0179	1.60	0.1127	
β_3	0.0109	0.49	0.6268	
β_7	0.5768	3.66	0.0004	
picknpay				0.2574
β_0	0.0149	1.88	0.0623	
β_3	-0.00322	-0.20	0.8391	
β_7	0.7327	6.56	0.0001	
pioneer				0.1573
β_0	-0.0006	-0.09	0.9274	
β_3	0.0129	0.92	0.3583	
β_7	0.4756	4.84	0.0001	
powertech				0.1089
β_0	0.0033	0.29	0.7747	
β_3	-0.0054	-0.23	0.8152	
β_7	0.6569	4.08	0.0001	
ppc				0.0809
β_0	0.0089	1.17	0.2427	
β_3	-0.0175	-1.14	0.2555	
β_7	0.3732	3.46	0.0008	
premier				0.1130
β_0	0.0039	0.39	0.6936	
β_3	0.0115	0.59	0.5585	
β_7	0.5916	4.27	0.0001	
rembrandt				0.3498
β_0	0.0297	4.08	0.0001	
β_3	-0.0146	-1.00	0.3182	
β_7	0.8226	8.02	0.0001	
barlows				0.4579
β_0	0.0069	1.22	0.2268	
β_3	0.01112	0.99	0.3255	
β_7	0.8058	10.11	0.0001	

blue-circle				0.1502
β_0	0.0062	0.68	0.4971	
β_3	0.0173	0.95	0.3416	
β_7	0.6164	4.82	0.0001	
clicks				0.1577
β_0	0.0126	1.31	0.1913	
β_3	0.0062	0.33	0.7455	
β_7	0.6651	4.93	0.0001	
sabrews				0.3725
β_0	0.0127	2.13	0.0355	
β_3	0.0178	1.49	0.1385	
β_7	0.7106	8.47	0.0001	
amic				0.3551
β_0	0.0076	1.01	0.3130	
β_3	0.0160	1.06	0.2908	
β_7	0.8647	8.16	0.0001	
sanland				0.0638
β_0	-0.0058	-0.87	0.3884	
β_3	-0.0016	-0.12	0.9043	
β_7	0.3024	3.22	0.0016	
sappi				0.2282
β_0	0.0118	1.30	0.1949	
β_3	0.0019	0.11	0.9164	
β_7	0.7937	6.23	0.0001	
sasol				0.3930
β_0	0.0021	0.35	0.7299	
β_3	0.0137	1.14	0.2565	
β_7	0.7374	8.68	0.0001	
seardel				0.0597
β_0	0.0091	0.79	0.4317	
β_3	-0.031	-1.35	0.1796	
β_7	0.5070	3.10	0.0024	
avi				0.1901
β_0	0.0153	1.98	0.0501	
β_3	-0.0125	-0.81	0.4192	
β_7	0.6004	5.51	0.0001	
aeci				0.2465
β_0	0.0018	0.26	0.7950	
β_3	0.0112	0.81	0.4192	
β_7	0.6308	6.46	0.0001	
afcol				0.1955
β_0	0.0043	0.49	0.6220	
β_3	0.0333	1.90	0.0594	
β_7	0.6635	5.38	0.0001	
afrox				0.1968
β_0	0.0094	1.14	0.2555	
β_3	-0.0102	-0.62	0.5364	
β_7	0.6442	5.57	0.0001	
amaprop				0.0275
β_0	0.0231	1.09	0.2782	
β_3	0.0418	0.99	0.3264	
β_7	0.6589	2.20	0.0295	
ang-alpha				0.1175
β_0	0.0095	1.33	0.1870	
β_3	0.0210	1.46	0.1458	
β_7	0.4242	4.20	0.0001	
tiger-oats				0.2774
β_0	0.0170	2.68	0.0085	
β_3	0.0027	0.22	0.8299	
β_7	0.6093	6.81	0.0001	

tongaat				0.3248
β_0	0.0014	0.22	0.8256	
β_3	0.0112	0.86	0.3907	
β_7	0.7111	7.79	0.0001	
dorbyl				0.2737
β_0	0.0055	0.70	0.4878	
β_3	-0.0129	-0.82	0.4164	
β_7	0.7582	6.82	0.0001	
hiveld				0.1713
β_0	0.0059	0.62	0.5337	
β_3	-0.0082	-0.43	0.6698	
β_7	0.6929	5.14	0.0001	
fedfund				0.2113
β_0	-0.002	-0.28	0.7778	
β_3	0.0079	0.55	0.5836	
β_7	0.5783	5.74	0.0001	
gf-props				0.2614
β_0	-0.0001	-0.02	0.9876	
β_3	0.0145	0.91	0.3623	
β_7	0.7311	6.55	0.0001	
santam				0.1297
β_0	0.0053	0.60	0.5527	
β_3	-0.002	-0.11	0.9129	
β_7	0.5584	4.44	0.0001	
sbic				0.2159
β_0	0.0074	0.99	0.3238	
β_3	0.0276	1.84	0.0687	
β_7	0.5792	5.47	0.0001	
sentrachem				0.2297
β_0	-0.0057	-0.59	0.5566	
β_3	-0.0063	-0.33	0.7440	
β_7	0.8384	6.19	0.0001	
abercom				0.1494
β_0	-0.109	-1.05	0.2951	
β_3	0.0249	1.20	0.2345	
β_7	0.7041	4.80	0.0001	
boland				-0.0010
β_0	-0.0065	-1.25	0.2124	
β_3	-0.01	-0.96	0.3391	
β_7	0.1294	1.77	0.0795	
btrdun				0.1557
β_0	0.0045	0.55	0.5810	
β_3	0.0312	1.91	0.0584	
β_7	0.5278	4.59	0.0001	
goldstein				0.1291
β_0	0.0023	0.18	0.8580	
β_3	-0.0583	-2.30	0.0230	
β_7	0.6885	3.86	0.0002	
metkor				0.1325
β_0	0.0063	0.63	0.5325	
β_3	-0.002	-0.10	0.9198	
β_7	0.6430	4.56	0.0001	
nedcor				0.2085
β_0	-0.0001	-0.01	0.9950	
β_3	0.0283	1.91	0.0588	
β_7	0.5669	5.42	0.0001	
prima				0.0651
β_0	-0.0045	-0.66	0.5095	
β_3	-0.002	-0.14	0.8850	
β_7	0.3039	3.17	0.0020	

romatex				0.0848
β_0	-0.0032	-0.42	0.6743	
β_3	0.008	0.53	0.5954	
β_7	0.4107	3.85	0.0002	
fedfood				0.1323
β_0	0.0002	0.03	0.9791	
β_3	0.0279	1.71	0.0906	
β_7	0.4815	4.17	0.0001	
bankorp				0.2045
β_0	-0.0046	-0.62	0.5385	
β_3	-0.012	-0.81	0.4194	
β_7	0.5905	5.66	0.0001	
concor				0.0023
β_0	-0.0019	-0.14	0.8857	
β_3	-0.0204	-0.78	0.4373	
β_7	0.2601	1.41	0.1616	
iandj				0.1292
β_0	0.0179	2.11	0.0369	
β_3	0.0143	0.84	0.4018	
β_7	0.5169	4.33	0.0001	
ics				0.1293
β_0	0.0066	0.79	0.4317	
β_3	-0.0023	-0.14	0.8907	
β_7	0.5257	4.43	0.0001	
kanhym				0.0897
β_0	-0.0083	-0.69	0.4887	
β_3	0.0325	1.36	0.1758	
β_7	0.6089	3.62	0.0004	
lta				0.0751
β_0	-0.0098	-0.94	0.3501	
β_3	0.0353	1.70	0.0927	
β_7	0.4549	3.10	0.0024	
otis				0.0763
β_0	-0.0052	-0.59	0.5570	
β_3	0.0069	0.39	0.6960	
β_7	0.4084	3.30	0.0013	
		Average	adjusted-R^2	0.1777

APPENDIX J

INDUSTRIAL SHARES: SEEMINGLY UNRELATED REGRESSION MODEL FOR DEFAULT PREMIUM RISK, GOLD PRICE RISK AND RESIDUAL MARKET RISK (FACTORS 2, 4 AND 7)

Share	β-estimates	t-value	prob > |T|	adjusted-R^2
liberty				0.2715
β_0	0.0147	2.15	0.0334	
β_2	0.0187	1.03	0.3037	
β_4	0.2367	2.36	0.02	
β_7	0.7021	6.27	0.0001	
malbak				0.1988
β_0	0.0072	0.73	0.4650	
β_2	0.0207	0.80	0.4255	
β_4	0.4170	2.92	0.0043	
β_7	0.7832	4.91	0.0001	
mccarthy				0.0842
β_0	0.0096	0.83	0.4078	
β_2	0.0159	0.52	0.6037	
β_4	0.0016	0.01	0.9922	
β_7	0.7315	3.88	0.0002	
nampak				0.1967
β_0	0.0082	1.21	0.2289	
β_2	0.0079	0.44	0.6609	
β_4	0.2003	2.01	0.0469	
β_7	0.5896	5.30	0.0001	
ok				0.1878
β_0	-0.0039	-0.52	0.6055	
β_2	-0.0083	-0.41	0.6843	
β_4	0.2656	2.36	0.0201	
β_7	0.6412	5.10	0.0001	
pepkor				0.1061
β_0	0.0185	1.66	0.0991	
β_2	0.0453	1.54	0.1269	
β_4	0.0605	0.37	0.7111	
β_7	0.7051	3.88	0.0002	
picknpay				0.2759
β_0	0.0164	2.09	0.0387	
β_2	-0.036	-1.73	0.0867	
β_4	0.2532	2.20	0.0301	
β_7	0.8184	6.36	0.0001	
pioneer				0.1524
β_0	0.0011	0.15	0.8780	
β_2	0.0284	1.52	0.1304	
β_4	0.2374	2.30	0.0232	
β_7	0.4705	4.09	0.0001	
powertech				0.1136
β_0	0.0039	0.35	0.7297	
β_2	0.0077	0.25	0.7993	
β_4	0.1092	0.65	0.5174	
β_7	0.7930	4.23	0.0001	
ppc				0.0798
β_0	0.0088	1.15	0.2536	
β_2	-0.0058	-0.29	0.7756	
β_4	-0.0011	-0.01	0.9923	
β_7	0.4719	3.75	0.0003	

premier				0.0871
β_0	0.0064	0.64	0.5238	
β_2	-0.015	-0.56	0.5733	
β_4	0.3807	2.59	0.0108	
β_7	0.486	2.96	0.0037	
rembrandt				0.3465
β_0	0.0313	4.26	0.0001	
β_2	-0.0074	-0.38	0.7029	
β_4	0.2626	2.44	0.0162	
β_7	0.9243	7.70	0.0001	
barlows				0.4657
β_0	0.0084	1.49	0.1378	
β_2	0.0126	0.84	0.3999	
β_4	0.2210	2.67	0.0087	
β_7	0.9210	9.97	0.0001	
blue-circle				0.1201
β_0	0.008	0.86	0.3901	
β_2	0.005	0.21	0.8379	
β_4	0.2570	1.89	0.0614	
β_7	0.6213	4.09	0.0001	
clicks				0.1459
β_0	0.0149	1.53	0.1277	
β_2	-0.0187	-0.73	0.4671	
β_4	0.3503	2.47	0.0152	
β_7	0.6519	4.11	0.0001	
sabrews				0.3746
β_0	0.0139	2.33	0.0213	
β_2	0.012	0.76	0.4482	
β_4	0.1687	1.93	0.0565	
β_7	0.8251	8.44	0.0001	
amic				0.3443
β_0	0.0097	1.27	0.2050	
β_2	0.0104	0.51	0.6083	
β_4	0.2976	2.66	0.0088	
β_7	0.9520	7.64	0.0001	
sanland				0.0599
β_0	-0.0054	-0.80	0.4238	
β_2	0.0012	0.07	0.9454	
β_4	0.0608	0.62	0.5376	
β_7	0.3554	3.24	0.0016	
sappi				0.2163
β_0	0.0132	1.44	0.1513	
β_2	0.034	1.41	0.1612	
β_4	0.2042	1.52	0.1313	
β_7	0.8619	5.75	0.0001	
sasol				0.4232
β_0	0.0042	0.71	0.4802	
β_2	0.0348	2.22	0.0281	
β_4	0.2916	3.37	0.001	
β_7	0.8157	8.44	0.0001	
seardel				0.0709
β_0	0.00779	0.67	0.5023	
β_2	-0.0094	-0.30	0.7610	
β_4	-0.1670	-0.98	0.3273	
β_7	0.6811	3.59	0.0005	
avi				0.1559
β_0	0.0169	2.14	0.0345	
β_2	-0.0134	-0.64	0.5254	
β_4	0.2763	2.37	0.0192	
β_7	0.5813	4.48	0.0001	

aeci				0.2841
β_0	0.0023	0.34	0.7357	
β_2	0.0231	1.29	0.2013	
β_4	0.0524	0.53	0.5994	
β_7	0.7834	7.06	0.0001	
afcol				0.1475
β_0	0.0063	0.70	0.4881	
β_2	0.011	0.46	0.6472	
β_4	0.2581	1.94	0.0545	
β_7	0.6818	4.60	0.0001	
afrox				0.2073
β_0	0.0105	1.29	0.2008	
β_2	0.0422	1.95	0.0542	
β_4	0.1733	1.44	0.1518	
β_7	0.7147	5.33	0.0001	
amaprop				0.0086
β_0	0.0254	1.18	0.2411	
β_2	0.0419	0.73	0.4643	
β_4	0.2768	0.88	0.3824	
β_7	0.6283	1.78	0.0772	
ang-alpha				0.1104
β_0	0.0099	1.37	0.1724	
β_2	0.0119	0.62	0.5346	
β_4	0.0329	0.31	0.757	
β_7	0.5187	4.39	0.0001	
tiger-oats				0.2804
β_0	0.0187	2.94	0.0039	
β_2	0.0195	1.16	0.2492	
β_4	0.2583	2.77	0.0066	
β_7	0.6507	6.24	0.0001	
tongaat				0.3112
β_0	0.0027	0.41	0.6806	
β_2	0.013	0.75	0.4577	
β_4	0.1784	1.85	0.0669	
β_7	0.7972	7.41	0.0001	
dorbyl				0.2585
β_0	0.0069	0.86	0.3939	
β_2	-0.004	-0.19	0.8507	
β_4	0.2267	1.93	0.056	
β_7	0.8402	6.41	0.0001	
hiveld				0.1829
β_0	0.0081	0.85	0.3963	
β_2	0.0587	2.32	0.0221	
β_4	0.3170	2.27	0.0254	
β_7	0.6803	4.36	0.0001	
fedfund				0.1998
β_0	0.0002	0.03	0.9761	
β_2	-0.0009	-0.05	0.9616	
β_4	0.3356	3.16	0.0020	
β_7	0.5568	4.70	0.0001	
gf-props				0.2493
β_0	0.0031	0.39	0.6986	
β_2	-0.002	-0.10	0.9199	
β_4	0.4820	4.09	0.0001	
β_7	0.6615	5.04	0.0001	
santam				0.1300
β_0	0.0064	0.72	0.4710	
β_2	-0.021	-0.89	0.3742	
β_4	0.1910	1.45	0.1491	
β_7	0.6208	4.23	0.0001	

sbic				0.2125
β_0	0.0091	1.20	0.2324	
β_2	0.01	0.50	0.6176	
β_4	0.2141	1.93	0.0560	
β_7	0.6742	5.45	0.0001	
sentrachem				0.1928
β_0	-0.0032	-0.32	0.7459	
β_2	0.0086	0.33	0.7430	
β_4	0.3822	2.64	0.0095	
β_7	0.8135	5.03	0.0001	
abercom				0.1227
β_0	-0.0089	-0.84	0.4002	
β_2	0.0402	1.43	0.1564	
β_4	0.2583	1.66	0.0999	
β_7	0.7027	4.04	0.0001	
boland				-0.0025
β_0	-0.0069	-1.32	0.1898	
β_2	0.0088	0.63	0.5280	
β_4	-0.0489	-0.64	0.5237	
β_7	0.1726	2.02	0.0458	
btrdun				0.1637
β_0	0.0049	0.60	0.5468	
β_2	-0.0041	-0.19	0.8493	
β_4	0.0274	0.23	0.8191	
β_7	0.6939	5.19	0.0001	
goldstein				0.0579
β_0	0.0042	0.32	0.7530	
β_2	-0.0044	-0.13	0.8998	
β_4	0.3655	1.88	0.0621	
β_7	0.5870	2.71	0.0077	
metkor				0.1280
β_0	0.0071	0.71	0.4816	
β_2	-0.0023	-0.09	0.9324	
β_4	0.1341	0.91	0.3656	
β_7	0.7427	4.51	0.0001	
nedcor				0.1944
β_0	0.0017	0.22	0.8228	
β_2	-0.0192	-0.96	0.3366	
β_4	0.2408	2.18	0.0312	
β_7	0.6251	5.07	0.0001	
prima				0.0575
β_0	-0.0036	-0.52	0.6031	
β_2	0.0149	0.82	0.4151	
β_4	0.1386	1.38	0.1717	
β_7	0.3068	2.73	0.0074	
romatex				0.0692
β_0	-0.0026	-0.34	0.7331	
β_2	-0.0074	-0.36	0.7160	
β_4	0.0808	0.72	0.4745	
β_7	0.4574	3.64	0.0004	
fedfood				0.1286
β_0	0.0016	0.20	0.8452	
β_2	-0.0346	-1.59	0.1156	
β_4	0.1955	1.62	0.1085	
β_7	0.5346	3.96	0.0001	
bankorp				0.1808
β_0	-0.0031	-0.41	0.6833	
β_2	-0.0051	-0.26	0.7980	
β_4	0.2449	2.21	0.0290	
β_7	0.6109	4.94	0.0001	

concor				0.0029
β_0	-0.0021	-0.16	0.8765	
β_2	-0.0433	-1.24	0.2169	
β_4	0.0177	0.09	0.9268	
β_7	0.3135	1.46	0.1483	
iandj				0.1178
β_0	0.0195	2.27	0.0250	
β_2	0.0074	0.33	0.7455	
β_4	0.2224	1.77	0.0797	
β_7	0.5513	3.93	0.0001	
ics				0.1189
β_0	0.0084	0.99	0.3266	
β_2	-0.017	-0.75	0.4545	
β_4	0.2772	2.22	0.0282	
β_7	0.5137	3.69	0.0003	
kanhym				0.0604
β_0	-0.0066	-0.54	0.5908	
β_2	0.033	1.02	0.3092	
β_4	0.212	1.19	0.2372	
β_7	0.6115	3.07	0.0027	
lta				0.0428
β_0	-0.0075	-0.70	0.4823	
β_2	-0.0149	-0.53	0.5985	
β_4	0.3127	2.00	0.0475	
β_7	0.3853	2.21	0.0289	
otis				0.0905
β_0	-0.0044	-0.51	0.6136	
β_2	-0.023	-1.00	0.3211	
β_4	0.1151	0.90	0.3711	
β_7	0.5015	3.50	0.0007	
		Average	adjusted-R^2	0.1690