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Portfolio construction in South Africa with regard to the Exchange Rate

A dissertation presented by

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to

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Abstract

In South Africa the exchange rate receives a large amount of attention, due to its volatility and its perceived effect on share returns. This dissertation examines the international literature regarding exchange rate exposure and replicates their methods in a South African context to determine the model that finds the most exchange rate exposure.

With this model, and a few variations, the persistence of exchange rate exposure is examined, where it is found that a few shares consistently act as the best hedges against R/$ depreciation and similarly a few shares are consistently the best at exploiting Rand strength. With this in mind two hedging techniques are compared in their ability to protect against a R/$ depreciation, and simultaneously provide market related returns, against the ITRIX exchange traded fund. It was found that the methods were successful in that they were able to hedge against R/$ depreciation while still participating in the recent rapid growth on the J.S.E.

The last section of the thesis examines the pricing of the exchange rate, where it is found that pricing is not stable but is significant for long periods of time. This suggests that if the Rand continues to experience long periods of weakness or strength exposure to the exchange rate will be penalised or rewarded.

The results of the dissertation show the importance of considering exposure to the exchange rate when forming portfolios of shares.
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Chapter 1: Introduction

1.1 Justification

Over the past few years the Rand has received considerable attention from the domestic media. This public debate has ranged in scope from the 'correct' level of the R/$ exchange rate to the effect that the level of the R/$ exchange rate has on the economy. This concern stems from the period until the end of 2001 when the Rand was viewed as a one-way bet and consistently reached new lows. Recently however the Rand has bucked this trend and has shown periods of strength. The history of the value of the Rand is best displayed by the following graph (fig. 1.1) which shows the R/$ exchange rate from January 1995 to June 2006.

![Figure 1.1: History of R/$ exchange rate](image-url)
Chapter 1: Introduction

As can be seen the R/$ exchange rate reached a turning point at the beginning of 2002 and has been relatively strong since then. The earlier consistent depreciation of the Rand still lingers in the minds of many and in the media.

There is a concern, though not unanimous, that the R/$ could revert to its previous trend and once again be a consistently depreciating currency. The R/$ exchange rate is also still volatile and is liable to periods of weakness. With these scenarios in mind investment in the J.S.E. needs to be investigated with regards to sensitivity to the R/$ exchange rate. This is particularly pertinent if one wishes to maintain one's wealth relative to the rest of the world. The purpose of this study is to investigate the relationships between shares in the Top 40 index and the exchange rate and, if possible, devise a method that is able to mitigate the effect of a depreciation in the R/$ exchange rate without the expense and complications of currency positions.

1.2 Thesis Outline

The remainder of the dissertation is organised as follows:

Chapter 2 provides a review of the literature regarding exchange rate exposure. Chapter 3 provides an examination of the attention that the exchange rate and particularly hedging against the exchange rate by using equity investments gets in the domestic media. Chapter 4 provides an examination of the most popular models used to find exchange rate exposure in the literature and evaluates them in the South African context. Chapter 5 provides a method of examining the consistency of exchange rate exposure in South Africa and leads to Chapter 6 where methods of hedging exchange rate exposure are examined. Chapter 7 examines the pricing of exchange rate exposure in South Africa and is followed by the last chapter, Chapter 8, where the conclusions are discussed.
Chapter 2: Literature review

Due to the relatively short period of time that exchange rates have been floating, exchange only began to be floated after the collapse of the Bretton-Woods system in 1973, the concept of exposure to the exchange rate is relatively new in the formal literature. The earliest papers on the subject were published in the eighties and were primarily concerned with defining exchange rate exposure and examining theoretical models, empirical research was only conducted in the early nineties. This empirical research surprisingly gave little evidence of significant exposure even though, theoretically, exchange rate exposure should be widespread for reasons that will be examined later.

As the literature developed, various explanations were given for the limited exposure witnessed in studies. These predominantly related to the grouping of non-homogenous companies into portfolios and examining the portfolio exposure to an exchange rate or grouping exchange rates into trade-weighted exchange rates and measuring company or portfolio exchange rate exposure to a trade weighted exchange rate when a portfolio or company may not be exposed to certain currencies that are constituents of the trade weighted exchange rate. Solving these problems is not necessarily a simple task. Examining exposure on the firm level will require the exchange rate chosen to apply to all of the firms. Similarly, picking a bilateral exchange rate instead of a trade-weighted exchange rate will only be valid if all of the firms are exposed to that bilateral rate. Attempts have been made to solve these problems by finding the determinants of exchange rate exposure in order to a priori select firms or portfolios that are exposed to exchange rates and then test these firms or portfolios. Papers investigating the determinants of exposure have suggested that
exposure increases as the level of foreign involvement increases (see, for example, Jorion (1990)). This has lead to studies focusing on examining the foreign exchange exposure of multinationals and exporting companies, as these firms typically have the greatest degree of foreign involvement. Ironically these are the firms most able and likely to hedge exchange rate exposure, as noted by Bartov and Bodnar (1994) amongst others.

Another common topic in the literature is the question over whether to use contemporaneous or lagged exchange rates. If markets are efficient one would expect there to be no lagged relationship between returns of shares and returns of the exchange rate. The argument, as presented by Bartov and Bodnar (1994), for the use of lagged exchange rates is that since floating exchange rates have been implemented relatively recently, it is possible that investors have not been able to correctly estimate the relationship between exchange rate innovations and future returns of each company. Bartov and Bodnar argue that investors instead rely on quarterly statements released by firms to correct for mispricing and there is therefore an opportunity for above market, abnormal returns if one is able to correctly estimate the exposure of companies using contemporaneous exchange rate innovations. Benson and Faff (2003) provided a study into these and other problems in exchange rate exposure and found their sample of funds to be more exposed to a bilateral, contemporaneous exchange rate than to lagged exchange rates or trade weighted exchange rates.

Surprisingly, given the volatile nature of the Rand, there is a paucity of research into the exposure of South African firms to the Rand. Barr and Kantor (2005) examined exposure to the nominal and real R/S exchange rate and were able to a priori categorise shares according to their location of sales and costs and assign a sign of exposure. They showed their method to be accurate as tests on the sign of the exposure coefficient confirmed their categorisation. The results and methodology of their study form a critical element of this thesis and will be examined at length in
Chapter 2: Literature review

later chapters. The remainder of this chapter reviews the key literature on the subject of exchange rate exposure.

Adler & Dumas (1984)

Adler and Dumas (1984) were the first to give a definition and method of measuring exchange rate exposure. They reasoned that exposure would only make sense if, amongst other requirements, it was possible to measure the exposure and hedge against it. They showed that exposure to the exchange rate is best measured using the regression coefficient of share returns on exchange rate innovations and in this way exposure to the exchange rate is similar to exposure to the market. Their paper pointed the direction later research would take by mentioning that the next steps in the literature would be to find a way of implementing their idea and thereafter finding the determinants of exposure. Adler and Dumas’ seminal paper laid the foundation for future research and exchange rate exposure was accepted to be the regression coefficient of a particular share or portfolio on the exchange rate. Their research did come with a caveat and that was that companies using their type of model to hedge their exposure may in fact be wasting their money as it would be pointless if investors could in fact hedge the companies’ exposure themselves.

Jorion (1990)

Jorion (1990) provided the first attempt to empirically examine exchange rate exposure. Jorion noted that even though a firm may be entirely domestically based, they may still have foreign exchange exposure through the costs of imported inputs or competing imported goods. Jorion also noted, as Dumas (1978) pointed out, that multinationals may reduce their exposure through hedging policies and, if these are
known and priced into the shares of the company, they will reduce the correlation between exchange rate innovations and the share price returns. This implies that the determinants of exposure are not easy to determine and this was verified by the later literature.

In his paper, Jorion (1990) altered Adler and Dumas' (1984) model, who suggested regressing share returns on exchange rate innovations alone, and used the following model to find exchange rate exposure:

\[
R_{it} = \beta_{ii} + \beta_{i1}R_{et} + \beta_{i2}R_{mt} + \eta_{it} \tag{2.1}
\]

Where:

- \( R_{it} \) is the monthly return of share \( i \) at time \( t \).
- \( R_{et} \) is the monthly return of a trade-weighted exchange rate at time \( t \).
- \( R_{mt} \) is the monthly return of the market index at time \( t \).

This was different from Adler and Dumas' (1984) specification in two respects. Firstly, Adler and Dumas (1984) specifically focused on the exposure to one bilateral exchange rate in their simplified world. They mentioned that if more exchange rates were to be examined they could be included and their coefficients estimated. They did not use a trade-weighted exchange rate. Secondly, Jorion added a term for the market index. The correlation between the betas of the Adler and Dumas' simpler model and the exchange rate coefficients in equation (2.1) was very high implying that the exchange rate coefficient in equation (2.1) could be interpreted in the same manner as that of the simpler model. Adding the market term also improved the \( R^2 \) of the model and reduced the contemporaneous correlation between the residuals in the system of equations. This was required to ensure that the coefficient estimates in equation (2.1) would be independent with respect to each
share, which was necessary when Jorion (1990) fitted a regression to examine the
determinants of the exchange rate betas. By fitting a market term in addition to the
exchange rate term Jorion (1990) was able to remove most of the contemporaneous
correlation in the residuals.

Jorion (1990) mentioned that equation (2.1) was valid if the innovations in the share
prices and the exchange rate could be considered unanticipated. It could be argued
that as there is a forward market for exchange rates, not all of the movement in the
exchange rate is unanticipated but, as Jorion (1990) pointed out, the forward rate is
typically quite poor in explaining the variation in the exchange rate (Jorion (1990)
mentions an $R^2$ of 5%) and hence one can consider the movements in the exchange
rate to be unanticipated.

In his study, Jorion (1990) used three sample periods; 1971-1975; 1976-1980 and
1981-87 and tested the foreign exchange rate exposure of 287 U.S. multinationals.
He noted that there were few exchange rate co-efficients that were large relative to
their standard error, which implied a lack of widespread significant exposure, and
that the co-efficients are not consistent over time. This, Jorion (1990) reasoned,
could explain the paucity of empirical research on the relationship between share
returns and exchange rate innovations. Given the low level of exposure,
Jorion (1990) then proceeded to test whether exposure of each of the multinationals
was equal to zero or equal to each other. The results of the F-tests suggested that one
could strongly reject the notion of equal exposure and exposure equalling zero. Thus
even though the individual equations were not able to detect a large number of
significant exposures there were enough differences to reject all exposure being
equal to zero or equal to each other.

Jorion (1990) then examined the determinants of exposure to exchange rate
fluctuations, knowing that it was not equal to zero or equal across multinationals.
Following on from Levy (1983) who provided a theoretical reasoning for the increase in foreign sales leading to an increase in foreign exposure, Jorion found that exchange rate exposure was related to the fraction of sales made abroad, with exposure being positively correlated with the level of sales made abroad. This makes intuitive sense as one would expect a company that sells in a foreign currency and has domestic costs to benefit from a depreciation in its home currency more than a company that sells locally and has domestic costs. This assumes that the depreciation is beyond the level dictated by Purchasing Power Parity (PPP), a concept that shall be explored later.

Jorion (1990) was able to build on the definition of exposure as laid out by Adler and Dumas (1984) with a better specified model. Jorion detected that exposures are not equal across companies and that they rely on the level of foreign involvement of the company. Jorion’s specification was widely used in the literature following his paper but with slight variations such as different exchange rates and the use of lagged terms.

**Jorion (1991)**

Following on from his paper in 1990, Jorion (1991) examined the pricing of exchange rate exposure using U.S. stocks. Jorion pointed out that share prices and the value of the exchange rate are determined simultaneously and thus a significant relationship is not necessarily an indication of causality. It could be possible that the exchange rate and share prices are both moving in response to a third factor, such as the change in interest rates or money supply. To investigate the possibility of exchange rate innovations being proxies for other determining factors, Jorion (1991) constructed a multi-factor arbitrage model using the six terms specified by Roll and Ross (1986) and added the orthogonal component of the exchange rate as a seventh factor. Jorion also examined a two-factor model, where the first factor was a term
for the value-weighted market return and the second factor was the orthogonalised trade weighted exchange rate innovation.

Jorion (1991) used the same periods of data he used in 1990, the entire period was from January 1971 to December 1987 and was split into three sub periods; 1971-1975, 1976-1980 and 1981-1987. He formed 20 value-weighted industry portfolios using shares listed on the New York Stock Exchange (NYSE) and examined the exposure to the exchange rate for the two-factor and seven-factor models. Jorion found that, in general, the exposure to the exchange rate of each portfolio was similar for both the two and seven factor models. This indicates that exposure to the exchange rate is not simply a proxy for exposure to other economic factors. This result is important and it shows the validity of relating a movement in a share price to the exchange rate. This still does not indicate a direction of causality but later studies (such as Bartov and Bodnar (1994)) found a relationship between the lagged exchange rate and share prices, indicating that exchange rates affect share prices (but not precluding that market prices affect exchange rates). Their results and this one from Jorion together justify the use of exchange rate terms as exogenous variables to explain the innovations in share prices.

Although the exchange rate exposure of each portfolio using the two-factor and seven factor models were similar, the exposures were different between portfolios. Jorion found that it was possible to reject the hypothesis of equal exposure to the exchange rate with a significance level lower than 1%. Similarly to his paper in 1990, where he used firm data, Jorion was able to show that, in general, industries that export benefit from an exchange rate depreciation and industries that import suffer from an exchange rate depreciation.

Using the two-factor model, Jorion found that the pricing of the exchange rate was small and unstable. The pricing term for the entire period was 0.00033, which is
neither economically nor statistically significant. A similar result for the seven-factor model again showed that the pricing of the exchange rate was small, unstable and not significant. This showed that U.S. investors do not price exchange rate risk.

Jorion (1991) was able to show that the exchange rate was not just a proxy for other economic forces that affect share prices, and this is an assumption that will be made in this thesis. He was also able to show that although there are cross-sectional differences to exposure to the exchange rate between different industries, and the sample period included periods of Dollar volatility, U.S. investors did not price exchange rate exposure. This is an interesting result and parts of Jorion’s study are replicated later in this thesis to investigate if exchange rate risk is priced in the South African context.

**Loudon (1993)**

Loudon examined the exchange rate exposure of 141 Australian firms using monthly data from 1984 to 1989, the first six years that the Australian Dollar (AUD) was floated. Loudon reasoned out that in order for a company to make informed decisions about hedging their foreign exchange exposure they need reliable measures of the companies’ exposure to the exchange rate and whether investors price exchange rate risk.

Loudon, following on from Jorion (1990) categorised the nature of exposure into three distinct types; Translation exposure, Transaction exposure and Operating Exposure. Translation exposure refers to the sensitivity of the value a firm’s foreign investments, measured in the home currency of the firm, to the exchange rate. Transaction exposure is the sensitivity of a firm’s settlement values in the home currency of the firm to contracts denominated in foreign currency, such as imports,
to the exchange rate. Operating exposure reflects the ability of a firm to maintain cost competitiveness in response to exchange rate innovations. This exposure can arise from the price of competing goods or the change in buying power of the public, which are affected by the exchange rate and thus even domestic firms could have a theoretical exposure to the exchange rate. To minimise omitted variable bias, a market term is added, as in Jorion (1990), to the simple model proposed by Adler and Dumas (1984). Loudon pointed out that the use of a trade-weighted exchange rate may be incorrect as it implies that the exchange rate exposure is the same for each currency across companies. If this assumption is invalid the resulting exposure would be biased downward as currencies that have no exposure, or whose exposure has the opposite sign to at least one of the basket of currencies, would average out some of the exchange rate exposure. Nonetheless, Loudon used a trade-weighted exchange rate, as the alternative, several bilateral exchange rates, would be subject to multicollinearity.

Loudon, in a similar fashion to Jorion (1990), pointed to research, in this case Meese (1990), which showed that the movements in the exchange rate were unpredictable, and thus one need not use models to separate the expected from the unexpected component of the exchange rate as the entire movement in the exchange rate could be considered unexpected.

Loudon calculated the returns of the exchange rate such that a depreciation was associated with a negative return and an appreciation was associated with a positive return. With this in mind, Loudon found that resource companies had an average exposure of -.309 while industrials had an average exposure coefficient of 0.099. Though the standard errors of these results were not given, one can infer that, on average resource companies gave better returns when the AUD depreciated, while industrials gave better returns when the AUD appreciated.
Loudon tested to see if this difference in exposure was significant. Using both a two sample t-test and a Mood test, loudon found that there was a significant difference in exposure between the resource and industrial industries at lower than a .1% significance level. Similarly to Jorion (1990) who found exposure in only 5.2% of his sample of shares shares, loudon only found significant exposure, at the 5% level, in 9 of the 141 companies examined, which is only slightly more than one would expect if exposure was not a determinant for any of the shares. Loudon also found that the inclusion of an exchange rate term did not increase the $R^2$ greatly. Loudon found his results to be robust with respect to the choice of the currency (either trade-weighted exchange rate or U.S.$), heteroskedasticity, parameter instability, autocorrelation and the 1987 Stock market crash.

Loudon, using Jorion's (1990) methodology, was able to find cross-sectional differences in exposure between resource and industrials, with resources gaining from a depreciation and industrials gaining from an appreciation in the exchange rate. This has applications in the South African context either as a guide to optimising exchange rate exposure or as a means of eliminating it. Loudon reinforced the justification for not using the forward market to estimate the unknown changes in the exchange rate, mentioning that it had very little explanatory power. This approach is followed in this thesis, implying that innovations in the R/$ exchange rate are considered to be unexpected.

**Bodnar and Gentry (1993)**

Bodnar and Gentry (1993) examined the exchange rate exposure of industries in Canada, Japan and the U.S.A. using monthly data covering 1979 to 1988 for the U.S.A. and Canada and from September 1983 to the end of 1988 for Japan. Similarly to Jorion (1990) and Loudon (1993) they pointed to research, in this case by Meese and Rogoff (1983), which showed that it is not possible to accurately
predict changes in nominal exchange rates and therefore one can consider innovations in the exchange rate to be unexpected. Bodnar and Gentry slightly altered Jorion's (1990) model to incorporate excess returns, giving equation (2.2).

\[ R_{it} - r_{ft} = \beta_{0t} + \beta_{1t}(R_{mt} - r_{ft}) + \beta_{2t}R_{it} + e_{it} \]  

(2.2)

Where

- \( r_{ft} \) is the risk free rate of return in month t.

A depreciation of the exchange rate was represented by a negative return and an appreciation was represented by a positive return.

Equation (2.2) is effectively an extension of the market model, with an extra term for the exchange rate. Bodnar and Gentry found higher levels of exposure than had been found before with 28%, 21% and 35% of the industries in the U.S.A., Canada and Japan respectively having significant exposure at the 10% level. As Jorion (1990) had noted, the determinants of exposure are complex and Bodnar and Gentry suggests that the low level of exposure could be due to firms participating in activities that have different exposures or even actively hedging their exposure. They point out that firms with the highest theoretical exposure are the most likely to actively participate in hedging that exposure and thus categorising shares \textit{a priori} with respect to their exposure is not straightforward. Bodnar and Gentry tested whether exposure was equal to zero for all of the industries in each of the countries and were able to reject this hypothesis in each country at the 5% level.

Bodnar and Gentry then examined the determinants of exchange rate exposure and investigated the effect of the ratio of exports to domestic production, the ratio of imports to domestic consumption, a dummy variable for traded or non-traded goods and a variable representing the value spent on oil and coal, which are priced in U.S.
Dollars (USD), on the exchange rate coefficient using regression. For the U.S.A. and Japan they added a variable representing the ratio of a company’s foreign assets to domestic assets to indicate the importance of foreign investments. They found that companies’ exposure was affected by these factors and that, in general, companies that exported would have a more negative exchange rate coefficient than companies that did not. Similarly they found that companies that imported would have a more positive exchange rate coefficient than those who do not, implying that exporters benefit from a depreciation and importers benefit from an appreciation of their home currency. In Japan and Canada it was found that the non-traded goods dummy variable was significant, implying that firms that do not trade overseas performed better than firms that did when the domestic currency appreciated. In Japan and Canada it was found that firms that rely on oil and coal benefited from a currency appreciation as its coefficient was positive, this was in contrast to U.S. firms that use oil and coal who benefited from a depreciation in the USD. Oil and coal are priced in USD so it was not expected to have an effect in the U.S.A., so this result was unexpected. For both Japan and the U.S.A. the coefficient for the level of foreign investment was negative, indicating industries with large investments in foreign countries suffered when their domestic currency appreciated. With the U.S. oil and coal users as an exception these results confirmed the theoretical determinants of exposure and were not surprising.

Bodnar and Gentry were able to confirm the determinants of exchange rate exposure, effectively the level of foreign involvement, and thus allow the possibility of a priori classification with respect to exposure. They also reaffirmed the notion that industries are not homogenous with respect to their exchange rate exposure thus justifying further research.
Khoo (1994) examined the exchange rate exposure of mining stocks in Australia using monthly data from 1980 to 1987 and found the proportion of stocks with significant exchange rate exposure to be small. Khoo pointed out however that regression will only find the exposure of a company's share price, and hence its expected future dividend flow, to exchange rate fluctuations. This implies that one is only capturing exposure that has not already been hedged by the company.

Khoo examined the specification of the regression model with respect to the number of coefficients to include. An argument for only including a market and exchange rate terms was provided, with the justification being that since the true generating process is unknown, and the specification of other independent variables is subjective, and subject to multicollinearity problems, the simpler model would be used. This provided further justification for Jorion’s (1990) model. Khoo pointed to research by Mark (1990) that showed that Real and Nominal currency fluctuations were very highly correlated for the U.K., Canada, Belgium, France, Germany, Japan and Italy. This implied that the difference in terms of terms of regression statistics between the use of a real or nominal exchange rate would be minimal. Khoo decided to use a nominal exchange rate as to use real exchange rate would imply that the other terms in the equation would have had to have been adjusted for inflation as well, which would not allow the model to be interpreted in terms of the market model.

In order to evade the problems associated with changing exposure and the effect that this would have on regression coefficients, Khoo only examined the exposure of mining companies, the justification being that these companies would find it more
difficult to change their product line or move their operations abroad than a typical manufacturing company would. This only suggests that mining companies would find it more difficult than other types of companies to change their exposure, as one method of changing exposure is not available to them. It does not imply that mining companies are unable to hedge their exposure and their ability to hedge their foreign exchange exposure, either by importing equipment or through currency positions, may be the reason for the apparent lack of exposure of mining companies.

Khoo used more than one bilateral exchange rate for certain firms depending on the theoretical exposure of their category of production, which was gauged by the currency that was used in the primary export and import markets of each category (for example the AUD/USD and the AUD/ZAR were used for Gold companies). The U.S. Dollar was always used as most commodities are priced in dollars. Khoo found that while the market terms were generally significant, as expected, in many instances exchange rate terms were insignificant and in some cases they had the “wrong” sign. This could be due to companies having their own hedge policies or importing from countries that they export to and thus negating their exposure. Khoo pointed out that Australian mining companies typically have a large portion of their debt denominated in USD, this also acts as a hedge and diminishes the foreign exchange exposure of companies as their debt payments in terms of their local currency rise as their revenues rise in their local currency when the currency depreciates.

Khoo also formed market-weighted portfolios of gold, oil and coal companies to examine the exposure of groups of homogenous (with respect to the exchange rate) shares. The gold and oil portfolios had significant negative exposure to the AUD/USD exchange rate, implying that exposure could be enhanced by grouping homogenous companies into portfolios.
Khoo showed that exposure to the exchange rate in Australia is not as widespread as commonly believed and pointed out reasons for this. He also showed that it was possible to increase exposure to the exchange rate by forming portfolios of homogenous companies. This is interesting as the portfolios are formed according to their industry, suggesting that some industries have significant exposure to the exchange rate and that these can be determined *a priori* according to their trade characteristics.

**Bartov and Bodnar (1994)**

Bartov and Bodnar provided two possible reasons for the apparent lack of success in previous attempts to find significant exchange rate exposure. The first is the inclusion of firms that are able to easily and cheaply react to exchange rate changes and firms that have minimal theoretical exposure to the exchange rate. The second is that Bartov and Bodnar believed that due to the relatively short period of time that exchange rates were floated, there was still mispricing by investors and shares did not move simultaneously with the exchange rate but rather a lag was involved. In order to correct for the first problem, Bartov and Bodnar only selected U.S. firms that were homogenous with respect to their exposure to the exchange rate in their operations and in their direction of movement in response to exchange rate changes. Bartov and Bodnar focused on firms that benefited from Dollar depreciation. Their method of selection involved selecting firms that had reported relatively large (greater than 5% of pre-tax profit) foreign currency adjustments to their financial statements for at least three of the previous five years and that at least 75% of these adjustments were increases (decreases) in profit in response to depreciation (appreciation) of the Dollar. This sample selection procedure reduced the number of shares under investigation to 208 and these were examined using quarterly data from 1978 to 1989. Because the sample selection procedure was designed to only incorporate shares with the same sign of exposure, later tests of exposure had to be
To investigate the mispricing of shares, Bartov and Bodnar used a similar model to that of Jorion (1990), except that the exposure was calculated as a two-step procedure. Firstly, each firm’s abnormal returns were calculated as the residuals of a regression of the firm’s returns on a term for the market. These abnormal returns were then regressed on the trade-weighted exchange rate to determine the exposure of a share to the exchange rate. In order to determine the time that investors took to realise the implications of an exchange rate fluctuation on shares’ returns, Bartov and Bodnar regressed abnormal share returns on a set of current and lagged innovations in the trade-weighted exchange rate. They found the average intercept of this equation to be approximately zero and not significant, implying that abnormal returns were zero when the exchange rate did not move. This was also true for the inclusion of the movement of the exchange lagged by three months. However, the average lagged term was significant while the average contemporaneous term was not. This showed that investors were either ignoring the exchange rate and only pricing according to the affected factors in the firm, which would only be released the next quarter, or that investors were systematically mispricing the exchange rate effect. Bartov and Bodnar did however point out that if a lagged relationship is significant, as the market begins to understand the true relationship between the exchange rate and abnormal returns the lagged relationship should diminish in significance and be replaced by a significant contemporaneous relationship.

This lead Bartov and Bodnar to investigate the stability of the exchange rate relationship. If investors were mispricing exchange rate effects due to the short period of time that the Dollar had been freely floated, then one would expect that as time progressed this mispricing would diminish. The results of the test suggested that the lagged relationship between the shares and the exchange rate had diminished in size after 1984 but that the contemporaneous exposure was still not significant.
To test for the economic significance of the lagged relationship, Bartov and Bodnar devised a trading strategy based on the movement of the exchange rate. Since their share selection mechanism had given them a selection of shares that should benefit from USD depreciation, their strategy was to sell short the selection when the previous quarter experienced a Dollar appreciation and to go long when the previous quarter experienced a USD depreciation. They found that their strategy gave an abnormal return of 4% per annum, which is significantly different from 0 at the 5% level. Bartov and Bodnar found that this return was lower in the second period, corresponding with their earlier result that the link between the lagged exchange rate and shares had diminished after 1984.

The results of Bartov and Bodnar’s investigation showed that even with a set of share selection criteria, the contemporaneous exposure of U.S. firms is not significant. There is, however, a diminishing lagged relationship that is both statistically and economically significant. This lagged relationship could explain the paucity of significant results beforehand but as investors realise this, the relationship should become contemporaneous. In the South African context, as mentioned in the informal literature review, the movement in some shares is linked to the exchange rate nearly every day, this would imply that the relationship between share returns and innovations in the exchange rate in South Africa should be contemporaneous and it would be surprising if it was instead lagged.

**Choi and Prasad (1995)**

Choi and Prasad pointed out that a firm level analysis was required to determine if exchange rate exposure was significant as, with other variables, each individual firm would have a different exposure and thus by creating portfolios without regard to theoretical exposure may average out the exposure and show a non-significant relationship. Even when considering the theoretical exposures of companies and
forming portfolios on this basis, one may in fact be averaging out exposure as companies may be less exposed to the exchange rate than one may \textit{a priori} assume due to the reasons pointed out by Bartov and Bodnar (1994) and Khoo (1994), such as hedging or importing equipment to compensate for exporting goods.

Choi and Prasad used a two-factor model, with one factor for the market and another for the exchange rate, to explain returns in U.S. multinationals. To avoid the problems associated with multicollinearity Choi and Prasad orthogonalised the exchange rate factor using the approach of Elton and Gruber (1991) and ran a side regression of the exchange rate on the market. This implied that Choi and Prasad were looking at the exposure of firms to the exchange rate after the component of the exchange rate that is determined by the equity market was removed. Choi and Prasad used the forward market to estimate the unexpected movement in the trade-weighted exchange rate, which they used as the exchange rate factor. Choi and Prasad set up two models, one using the real exchange rate and the other using the nominal exchange rate and investigated the differences in coefficients for the different specifications. They also looked at splitting companies' assets into their domestic and overseas components as a way to gauge the determinants of exchange rate exposure.

Ordinary Least Squares regression (OLS) was used to estimate the models for each of the shares investigated. Choi and Prasad found that 61 of the 409 firms examined had significant exposure at the 10\% level to the nominal exchange rate, this is not much higher than one would expect by chance. However, Choi and Prasad were able to reject the hypothesis that exchange rate exposure is zero for all multinationals at the 1\% level. Just as Khoo had hypothesised, the nominal exchange rate coefficient was very similar to the real exchange rate coefficient with 63 firms having significant exposure to the real exchange rate, with the 63 including the 61 that were exposed to the nominal exchange rate. Due to the similarity between the figures for the Nominal and Real exchange rates and the fact that the nominal exchange rate is
reported in financial statements, Choi and Prasad continued their study only using the Nominal exchange rate.

Choi and Prasad investigated the impact of omitted variable bias, in that Jorion’s (1990) model has only two factors and there may be other significant factors. Choi and Prasad added a term for the change in the three-month Treasury bill. They found that the inclusion of this term did not affect the previous results, in that 61 firms were again found to have significant exposure.

Choi and Prasad then investigated the determinants of exchange rate exposure by examining the effect that foreign sales revenue, foreign assets and foreign operating profit had on the absolute value of the significant foreign exchange exposure coefficients from 1985 to 1989. Each of these effects was measured separately to avoid multicollinearity. None of the determinants was significant for each of the five years, but each was significant in three of the five years. Foreign sales revenue and foreign assets were significant at the 10% level over the entire five-year period. This confirms the research by (Jorion 1990) who suggested that exposure is linked to the level of foreign involvement of a company.

Choi and Prasad noted that their sample period had two sub periods, the first characterised by USD strength, encompassing 1978 to 1985 and the second characterised by USD weakness from 1985 to 1989. This is similar to the South African situation where the period from 1996 to 2006 can be split in two sub periods characterised by different R/$ traits. From 1996 until the end of 2001, the Rand consistently depreciated, this trend then reversed and the period from 2002 until 2006 was characterised by firstly R/$ appreciation and then by relative stability. Choi and Prasad noted that the number of firms significantly exposed to the exchange rate increased in the weaker USD period. This result is interesting and suggests either that American exporters hedge against Dollar strength with options.
or that exposure has increased over time.

Choi and Prasad then examined the exchange rate exposure of industry portfolios using Seemingly Unrelated Regression (SUR) and found that, similarly to Jorion (1990), industry exposure is not widespread but that it is possible to reject the null hypothesis of equal exposure for each of the industries at the 2% level.

Choi and Prasad found significant differences in exposure between companies with different levels of foreign involvement. They also found that exposure changes over time and that more companies had significant exposure during periods of dollar weakness than in periods of dollar strength. It was found that 60% of companies with significant exchange rate exposure benefited from a dollar depreciation but that few industry portfolios had significant exchange rate exposure. This paper is particularly interesting as it provides several inferences about exposure in the U.S.A. that could be tested in the South African context and will be examined later.

**Liang and Mougoué (1996)**

Liang and Mougoué (1996) estimated the exchange rate risk premium of American depository receipts (ADRs). ADRs are negotiable, dollar-denominated certificates issued by a U.S. Bank representing shares held in a foreign country by a U.S. bank abroad. These certificates allow U.S. investors to gain easy access to foreign equity markets. Because they are dollar denominated, they are analogous, in the South African context, to a company that trades overseas and lists on the J.S.E in order to raise capital, such as Richemont and Liberty plc.

ADRs with underlying shares in Japan, the U.K. and South Africa were examined
using data from 1976 to 1990. It was found that ADRs were sensitive, at the 5% level, to fluctuations in the relevant bilateral exchange rate using a two-factor model. The first factor represented the U.S. market return and the second factor was the appropriate nominal bilateral exchange rate. Liang and Mougoué (1996) then investigated the pricing of exchange rate risk for ADRs. APT requires that the factors need to be independent with respect to each other and Liang and Mougoué investigated the pricing of exchange rate risk when the exchange rate was orthogonalised relative to the market and when the market was orthogonalised relative to the exchange rate. Liang and Mougoué termed the regression coefficient of the orthogonalised exchange rate “incremental foreign exchange risk” and the regression coefficient of the exchange rate, when the market term was orthogonalised, “total foreign exchange risk”.

Liang and Mougoué found that total exchange rate risk was priced. This is not entirely surprising as the exchange rate risk of the market is included with the incremental exchange risk. One would expect the market exchange risk to be priced as the market term is priced and the exchange risk of the market forms part of the risk that is priced. Liang and Mougoué found that incremental exchange rate risk is not priced. This result is interesting in that it shows that the only exchange rate risk that is priced is that that the market has and any risk beyond that should be diversified away. The principles of this study are repeated in chapter 7, where the pricing of exchange rate risk in South Africa is examined.

Chow, Lee and Solt (1997)

Chow, Lee and Solt, noting the previous lack of success in finding widespread significant exposure to exchange rates, examined the effect of changing the time horizon that exchange rate returns are measured over. Chow et al. examined the returns of U.S. stocks and bonds from March 1977 to December 1989 using
different horizons for returns. Chow et al. noted that exchange rate effects on share prices would be driven by the effect of the exchange rate on future interest rates and on future foreign cash flows. Following from Shapiro (1992), Chow et al. noted that exchange rate exposure could be split into two types of exposure, transaction exposure and economic exposure. Transaction exposure relates to the risk that exchange rates can change between the time that a contract is entered into, and the time that it is settled. Economic exposure relates the risk that changes in the exchange rate will affect the future long term earnings of the company and therefore the present value of the share price and is similar to the operating exposure of Loudon (1993). The longer the period used to measure returns, the more important economic exposure becomes relative to transaction exposure, as long term changes in the exchange rate are more likely to affect the future earnings of the company. Chow et al. use this reasoning to explain the inability of previous studies to detect exposure, as investors would not have been able to predict the future earnings of the company only using monthly returns.

Following Fama and French (1989), Chow et al. fitted terms for the dividend yield and term premium to portfolios' returns above the risk free rate and added a term for the real trade weighted exchange rate. Chow et al. ran the above regression for returns with horizons of 1, 3, 6, 12, 24, 36 and 48 months using autocorrelation adjustments for overlapping returns.

Chow et al. found that there was no significant relationship between a portfolio of equally weighted or value weighted NYSE shares and the exchange rate for any lag lower than 6 months. Both equally and value weighted portfolios had significant positive relationships when 6, 12 or 24 month lags were used to calculate returns. Chow et al. then investigated the exposure of 65 industry portfolios and found that with a 48-month horizon used for returns approximately 80% of the portfolios showed significant exposure at the 5% level.
This result adds another dimension to the problem of model specification with regards to finding exposure to the exchange rate, that of return horizon. While the justification that long term movements are more likely to be reflected in returns than short term fluctuations makes sense for a currency that is volatile around a trend that is stable, it does not necessarily apply to the Rand. As such, the influence of the horizon of returns in finding significant exchange rate exposure will be investigated in later chapters.

**Dominguez and Tesar (2001)**

Dominguez and Tesar (2001) noted that previous weak exposure in the literature might be due to several model related issues. One of these is the widespread use of a trade-weighted exchange rate. Dominguez and Tesar pointed out that shares may in fact only be exposed to one currency and by using a trade weighted exchange rate one is liable to bias the estimates of exposure downwards. They also pointed out that industry level aggregation may in fact mask exposure as it is possible that different firms within the same industry may have opposite exposure to an exchange rate. They also point out that one cannot restrict research to firms that engage in international trade as these are the companies that are in fact most likely to actively hedge their exposure.

Dominguez and Tesar used data from January 1980 to May 1999 and examined firm and industry exposure in Chile, France, Germany, Italy, Japan, the Netherlands, Thailand and the United Kingdom. They found significant exposure at the firm and industry level in each of the countries with up to 60% of the industries and 31% of the firms in Japan having a significant exposure to an exchange rate. Their results highlighted the importance of model selection in finding exchange rate exposure. As such, the difference in exposure between a trade-weighted and a bilateral exchange rate will be examined in Chapter 4.
Di Iorio and Faff (2001)

Di Iorio and Faff (2001) examined the foreign exchange exposure of industry portfolios in Australia using daily data from 1988 to 1998. Di Iorio and Faff hypothesised that one of the reasons for the lack of success in most of the previous literature in finding significant exchange rate exposure was that exchange rate exposure was not stable. To this end, Di Iorio and Faff investigated the stability of foreign exchange exposure in Australia as well as the difference in exposure between industries and the determinants of exchange rate exposure.

Di Iorio and Faff used 24 industry portfolios and examined both contemporaneous and lagged exchange rate exposure to each of the trade weighted exchange rate, the AUD/USD exchange rate and the AUD/JPY exchange rate in an extended market model. Di Iorio and Faff regressed the portfolio returns on to a term for the market, a term for the contemporaneous exchange rate and a term for the relevant exchange rate lagged by one day. A GARCH term was also added to control for conditional heteroskedasticity in daily data. Di Iorio and Faff noted that previous studies using lagged exchange rates did not use daily data (Bartov and Bodnar (1994) used quarterly data) and this brings into question the justification for the lagged exchange rate term. Bartov and Bodnar’s justification was that investors systematically mispriced securities and were only able to judge the true effects of exchange rate fluctuations when quarterly results were released from firms. If the exchange rate lagged by one day is significant it implies that investors are slow or hesitant to react to exchange rate fluctuations and would have implications for the efficiency of the Australian market. A lagged exchange rate term could reflect an indirect exposure as the share price may be reacting to something else that reacts to the exchange rate, even so if the lagged exchange rate is significant it implies that the link between the exchange rate and share prices is not evident to the market.
Di Iorio and Faff found a greater number of significant exposures to the exchange rate, below the 10% level, for both the contemporaneous and lagged terms, when the exchange rate was the AUD/USD than when the exchange rate was the trade weighted exchange rate or the AUD/JPY. In addition, there were a greater number of significant lagged relationships than significant contemporaneous relationships with each of the exchange rates.

Di Iorio and Faff split their sample into year-long sub-periods to test for the stability of exchange rate exposure. They found that the mean exposure of the portfolios under investigation did change throughout their sample period with a significant positive mean exposure in 1988, at the 5% level, dropping to a significant negative exposure in 1995, at the 5% level. As noted before, one of the problems with using portfolios of shares to measure exposure is the averaging effect of combining shares. Di Iorio and Faff’s result could be due to some shares’ negative exposure becoming more negative while the shares with positive exposures remained stable.

Di Iorio and Faff’s finding of exposure to the lagged daily exchange rate contrasts with Chow’s (1997) result for U.S. shares, where he recommended the use of returns with at least a 6-month horizon. It must be noted that Di Iorio and Faff did find fewer cases of exposure than Chow did and this could be the result of the noise introduced by using daily data. To avoid the noise associated with daily data, monthly data will be used in later chapters. The use of a longer time period would only be necessary if exposure to monthly movements was small and therefore the prevalence of exposure to monthly innovations in the exchange rate will be examined.

It would be ideal if exposure to exchange rate innovations was stable for a group of shares, in sign at least, as then one could predict the possible direction of movement.
Chapter 2: Literature review

of specific shares in response to a currency innovation. This would allow for hedging against currency movements by investing in shares. As such, the stability of exchange rate exposure will be investigated as part of Chapter 5 with the hope that exposure in the South African context is more stable than that found in Australia.

Benson and Faff (2003)

Benson and Faff examined the exchange rate exposure of 118 Australian unlisted international equity funds, which typically have more than 90% of their assets invested in international shares, from 1989 to 1999, a period characterised by large volatility in the AUD. Benson and Faff investigated the use of several models; a simple model with a term for the market and one for the exchange rate, as proposed by Jorion (1990), an extended model with a term for the orthogonalised MSCI index, to account for the international risk the funds were exposed to, a model with a set of bilateral rates instead of a trade weighted exchange rate and a model with just a term for the MSCI and the trade weighted exchange rate. Benson and Faff also investigated the stability of exchange rate exposure by dividing their sample period into three sub periods that corresponded to different phases in the AUD. Benson and Faff also examined the effect of a lagged exchange rate by including a term for the exchange rate lagged by one month. In addition, recognising the results of Chow et al. (1997) Benson and Faff investigated the use of returns with a larger horizon.

Benson and Faff found that 20% of the funds had significant exposure over the entire period at the 10% level using the basic model proposed by Jorion. This result is similar to the previous attempts at finding exposure in that it did not find widespread significant exposure. By using a set of bilateral exchange rates instead, the prevalence of exposure increased; 47% of the funds were significantly exposed to the AUD/USD exchange rate, 47% were significantly exposed to the AUD/UK£,
34% were significantly exposed to the Japanese Yen (JPY) and 19% were significantly exposed to the Deutschmark (DM). The reason that exposure to the trade-weighted exchange rate was not widespread was that the exposure to the USD was in general the opposite sign, with funds benefiting from a depreciation relative to the USD, to the exposure to the other currencies and thus the trade weighted exposure, as noted in the previous literature, was effectively averaging out the exposure to the bilateral rates.

Benson and Faff noted that exchange rate exposure was not consistent between the sub periods and reasoned that this could be due to increased hedging by firms after the Asian crisis. They did not find widespread exposure to the lagged exchange rate and, following the reasoning of Bartov and Bodnar (1994), this implies that exchange rate exposure is not mispriced in the Australian market.

Benson and Faff provided a study into most of the problems associated with finding exchange rate exposure. They added a new specification of model, that with a world market term and this specification will be examined in Chapter 4 along with the issues relating to bilateral or trade weighted exchange rates and the use of a lagged exchange rate.

Fraser and Pantzalis (2004)

Fraser and Pantzalis addressed the lack of widespread exchange rate exposure by using a firm specific weighted exchange rate instead of the usual trade-weighted or bilateral exchange rate. The weightings for the exchange rate were derived from the geographic location of foreign subsidiaries of each of the 310 U.S. mining and manufacturing firms examined. In order to allow for the possibility that investors take time to react to exchange rate innovations, Fraser and Pantzalis included a term
for the innovation in the exchange rate lagged by one month. Fraser and Pantzalis used two firm specific exchange rates, one where the weights for the exchange rate were derived from the ratio of subsidiaries in a foreign country over the total number of foreign subsidiaries and the other where equal weights were applied to the exchange rates of each of the countries that had subsidiaries in them. There are two problems with this specification; firstly, each weight should represent the value of subsidiaries in a country as a proportion of the total value of foreign subsidiaries instead of simply the proportion of subsidiaries in a country. Secondly, firms may be exposed to exchange rates, through competing imported goods, belonging to countries in which the firm has no subsidiaries.

The firm-weighted exchange rates were compared to the use of a trade-weighted exchange rate. Fraser and Pantzalis also investigated the region of trade, the percentage of subsidiaries that are foreign and the concentration of foreign subsidiaries in countries as determinants of exchange rate exposure. Fraser and Pantzalis found that there was more widespread significance to the trade-weighted exchange rate (91 of the 310 firms) than either of the firm specific exchange rates (35 for subsidiary weighted and 37 for the equally weighted exchange rate). The percentage of foreign subsidiaries was positively and significantly related to the size of exchange rate exposure. This implies that companies with more foreign subsidiaries are more exposed to the exchange rate. This relates to the translation exposure mentioned by Loudon (1993). Fraser and Pantzalis found that foreign sales increase exposure, as does the number of countries that a company operates in. These results confirm the general link that Jorion made in 1990 that a firm’s exposure is linked to the level of foreign involvement of a firm.

**Barr and Kantor (2005)**

Barr and Kantor focused their study on the forty largest shares in the J.S.E. They
noted that the Real R/$ exchange rate and the Nominal R/$ exchange rate are quite well correlated as the component of nominal exchange rate fluctuations that can be attributed to the difference in inflation between the U.S.A. and South Africa is typically quite small. Barr and Kantor grouped the constituents of the Top40 Index into three categories that were expected to react differently to innovations in the exchange rate; Rand Plays, Rand Hedges and Rand Leverage. Rand Plays were firms whose revenues and costs were incurred in Rands, such as banks and retailers. Rand Hedge companies’ revenues and costs were denominated in a foreign currency. These are firms that list on the J.S.E. but are based offshore such as Liberty plc and Richemont. Rand Leverage firms received their revenues in a foreign currency but incurred their costs in Rands. Typically Rand leverage firms derive most of their revenue through exports, in general mining companies will fit into this category.

Barr and Kantor hypothesised that Rand Plays should be negatively exposed to the exchange rate, implying a benefit from Rand appreciation, while Rand Hedge and Rand leverage companies should be positively exposed to the exchange rate, implying that they benefit from Rand depreciation. The reason that hedges and leverage companies benefit from a currency depreciation that is beyond that suggested by PPP is relatively obvious, their Rand revenues increase faster than their Rand costs. The reason that a Rand Play should depreciate if the currency depreciates is not as obvious. Barr and Kantor ascribed this relationship to foreign investors for whom a Rand depreciation implies diminished dollar dividends.

Empirical testing confirmed the hypothesised sign of exposure as nearly all of the shares examined had the same sign of exposure as that predicted by their respective category. The results and methodology of Barr and Kantor provide a large step forward in that they simultaneously address the issue of determinants of exposure and the prevalence of exposure; some companies cannot be neatly categorised into one of the three categories and their exposure reflects this. These results and
methodology will be examined at length in later chapters.

**Faff and Marshall (2005)**

Faff and Marshall pointed to research that showed that firms view risk differently and have different strategies for hedging risk. This applies to foreign exchange risk and Faff and Marshall thought that it could be partly responsible for the lack of success in finding widespread significant exposure in multinationals. Faff and Marshall focused on large multinationals that perceived they were vulnerable to foreign exchange risk and actively hedged this risk. They did not find widespread exposure to the exchange rate.

Exposure, as defined by Adler and Dumas (1984), only measures the exposure of share returns to exchange rate fluctuations and thus if a firm hedges exchange rate exposure, and investors know this, the firm will not have significant exchange rate exposure. This makes it difficult to estimate the exposure of a firm without looking at the hedging policies of a firm. This is a vital point and was raised by Jorion (1990). As such, the shares investigated in later chapters will not be restricted to those that have large overseas transactions, instead the shares will be selected on their market capitalisation and liquidity.

**Gao (2005)**

Gao (2005) used firm level data and focused on U.S. multinational’s exposure to an export-weighted exchange rate. Gao reasoned that in an efficient market investors would react to an unexpected change in the exchange rate by re-estimating the value of each company’s future earnings and thus the share price. The problem is to
determine the component of the exchange rate fluctuation that is unexpected, earlier studies, with the exception of Choi and Prasad (1995), had skirted around the issue by pointing to research that suggested that the innovations in the exchange rate were unexpected in any case. Gao used two different models to determine the unexpected movement in the exchange rate; an AR(1) process and a regression model including contemporaneous and lagged terms for money supply, interest rates, industrial production, net exports and the rate of inflation. Gao then split the exposure to the exchange rate into the exposure of foreign sales, the exposure of foreign production and a constant. He found that foreign sales exposure was significantly positive, at the 5% level and foreign production exposure was significantly negative at the 5% level. This implies that companies’ foreign revenues increase when the dollar depreciates, but that production overseas is reduced. This could be a result of multinationals moving production to the U.S. to take advantage of the depreciating currency as Bartov and Bodnar (1994) suggested may be happening. The results are consistent whether the exchange rate or the unexpected movement in the exchange rate is used to measure currency fluctuations as was suggested earlier.

The results suggest that while firms exports may increase, their foreign assets decrease and thus the net effect is small, possibly explaining the weak exposure that is prevalent in the literature. Gao has shown that if a multinational has apparent weak exposure it is possibly due to the movement of production or assets of the firm and thus the firm is hedging its risk. An important result that will be used in later chapters is that there is a minimal difference in results when comparing the use of the exchange rate or the unexpected movement in the exchange rate. This result was hypothesised by Bodnar and Gentry (2003) amongst others and shown to be true by Gao.
Ihrig and Prior (2005)

Ihrig and Prior set out to examine the exposure of firms to industry-based exchange rates as aside from broad trade-weighted exchange rates. They used monthly data between 1995 and 1999 for 901 U.S. firms and their sample included both multinationals and domestic firms. Using the model employed by Jorion (1990), Ihrig and Prior found that exchange rate exposure was more widespread when the exchange rate was measured with an industry-based exchange rate than the usual trade-weighted exchange rate. The level of exposure was still small, approximately 13% of the sample had significant exchange rate exposure at the 10% level, and this reflects the fact that even within industry based exchange rates, aggregating the exchange rate averages out the exposure and biases down exposure. Ihrig and Prior then investigated how levels of exposure change during exchange rate crises, they found that some firms were only exposed during exchange rate crises (44 of the 901 firms), reflecting that they were able to hedge normal exposure, while they were not able to cope with large fluctuations in the exchange rate. Surprisingly 93 of the 901 firms were only exposed in non-crisis periods. This suggests that these firms do not hedge against day-to-day movements but do hedge against large movements. 17 of the firms were exposed in both crisis and non-crisis periods.

Ihrig and Prior demonstrated that including currency crisis periods in a sample can lead to misleading levels of exposure, particularly if one views crisis events to be once-offs. As such, for most of this thesis the emerging market crisis and its effect on South Africa in August 1998 will be excluded, as the main purpose of this thesis is to investigate the normal link between exchange rate fluctuations and share price innovations.
Homma, Tsutsui and Benzion (2005)

Homma, Tsutsui and Benzion (2005) examined the efficiency of Japanese stocks with respect to exchange rate innovations by examining 114 firms using daily data from January 1983 to March 1986. Homma et al. used a model including terms for TOPIX, the stock index of the Japanese stock exchange, the call rate, firm size, debt ratio and the Yen-Dollar exchange rate. Homma et al. also decomposed exposure into the exposure of the ratio of foreign sales to total sales and the exposure of the ratio of net foreign assets to total assets, similarly to Gao (2005).

Homma et al. found the terms for firm size and firm debt ratio to be insignificant. They found the level of foreign assets to have a negative exposure but it was also not significant. Homma et al. split the sample period into five sub periods corresponding to different phases of growth in the TOPIX. They noted that the sign of exposure for the ratio of foreign sales and the ratio of foreign assets increasingly matched expectations as time progressed. Whereas previous studies into the stability of exchange rate exposure had reasoned that instability was a result of hedging by firms, Homma reasoned that the changing reaction to exchange rate innovations was due to increased efficiency in the Japanese market and that investors were increasingly acting correctly to exchange rate innovations. This is a similar argument to Bartov and Bodnar (1994), who reasoned that there was a lag involved in exposure as investors learnt the correct way to price exchange rates and that over time this lag will diminish. Homma’s result implies that Japanese investors react to the level of foreign sales and foreign assets a firm has and use the exchange rate to price shares appropriately. The idea of exchange rate exposure increasing over time as investors realise the correct price implications of an exchange rate innovation will be examined in later chapters as a test of the stability of exchange rate exposure.
**Dominguez and Tesar (2006)**

Dominguez and Tesar followed up on their 2001 study of exchange rate exposure by including terms representing firm size, international assets, competitiveness and an indicator variable for whether the firm is a multinational or not. Dominguez and Tesar (2006) found that exposure is not associated with industry affiliation, this result is important and could explain the apparent lack of exposure observed when industry based portfolios are used and contrasts the study by Khoo in 1994. Dominguez and Tesar (2006) found that the size of a firm does have an impact on its exchange rate exposure with smaller firms, in general, having greater exposure than larger firms. Similar to previous findings, Dominguez and Tesar (2006) find that exposure is linked to the level of foreign activities of a firm. Realising that even domestic firms should be exposed to exchange rate exposure through the pricing of competing imported products, Dominguez and Tesar (2006) tested to see if competitiveness of an industry, measured by the Herfindahl index, is a determinant of a firm’s exposure. They found that it was not. They did however find that exchange rate exposure is linked to the level of importing or exporting an industry undertakes. This reaffirms the categorisation employed by Barr and Kantor (2005) and the association between exposure and foreign involvement as presented by Jorion (1990).

**Conclusions**

With the exception of Benson and Fař (2003), Dominguez and Teas (2001) and Chow (1997) attempts to find widespread significant exposure to the exchange rate have been unsuccessful. The literature has provided several reasons for this lack of success such as model specification, mispricing by investors and hedging by companies. None of these issues has been thoroughly investigated in the South
African context with respect to the exchange rate. The literature has provided an array of model specifications and interpretations that will be investigated in the following chapters such as the type of exchange rate to use, whether to include a lagged exchange rate or not and the stability of the exchange rate.
Chapter 3:
Informal literature review

Commentary on the Rand/Dollar exchange rate features prominently in the South African media and this would suggest that market commentators believe that it is important in some way. The following section gives an overview of the informal domestic literature surrounding investment in the J.S.E. with regards to mitigating exchange rate risk. The domestic media’s attention on the Rand has primarily focused on two aspects of the Rand; when will it depreciate and which shares to hold when it does.

3.1 Finding Rand Hedges

Given that within the domestic press there is a belief that the Rand's level is a significant contributor to specific share prices, a notion of a “Rand Hedge” share has been formed. This is generally defined as a share that benefits from Rand weakness. “Resources stocks act as Rand Hedges” appeared in the Business Day on 25 November 2003 and suggested that investors should invest in resource stocks as Rand Hedges as it was simpler than sending money overseas. The article also noted that resource stocks have other exposures and that it was thus necessary to hold a diverse mix of Rand Hedges to reduce unwanted exposure to other factors such as the gold price. Alec Hogg posted an article on Moneyweb’s website in May 2005 defining Rand Hedges as shares whose Rand values increase as a result of Rand depreciation and similarly to “Resources stocks act as Rand Hedges” pointed out that investors could get protection from a depreciating currency simply by investing locally and avoiding the expense and complications involved with investing abroad. In an article in Business Day on 15 September 2006 titled “Softer Rand gives JSE a
Chapter 3: Informal literature review

welcome lift” Sasfin strategist Craig Pheiffer was quoted as attributing the increase in value of Rand Hedge shares to the movement of the Rand. There have been many other articles attributing share movements to the fluctuations in the Rand (see, for example, articles in Business day on 9 September 2006 (“Rand, gold eat at JSE’s gains”) and on 5 September 2006 (“Local stocks boosted by weaker rand”) by Ayanda Shezi amongst many others) and it is quite common to read comments such as these in the press. Some commentators, noting the high weighting of Rand Hedges in the Top40 Index, have even categorised the SATRỊX 40 as a Rand Hedge. In an interview with Alec Hogg on money web in July 2006 Mike Brown made this point, as did Vic de Klerk in an article in Fin week titled “Buy Satrix as a hedge” in June 2006.

In response to the weakening Rand many commentators have provided selections of shares they view to benefit the most from Rand weakness. On 11 September 2006 an article in the Business day titled “Whispers of Rand Hedges being heard” gave a list of possible Rand Hedges to invest in anticipation of a Rand depreciation. On 3 July 2006 an article titled “The market is looking for Rand Hedges” appeared in the Business Day, which examined a number of Rand Hedges such as Sasol, Sappi and resource companies.

Some commentators have differentiated between Rand Hedges and Rand plays such as Kirsty Laschinger in Finweek in August 2006 who examined the correlation between retailers and the R/S exchange rate. She noted that retailers seem to benefit from R/S appreciation as a result of cheaper imports and suffer from R/S depreciation due to expectations of higher interest rates. She also noted that foreign investors contribute to this relationship as they tend to sell shares on the J.S.E. when the Rand depreciates. This point was noted by Barr and Kantor (2005) and as foreign investors hold up to 40% of the value of listed retailers, it could play a large role in determining exchange rate exposure of these shares.
On Moneyweb on 4 May 2005 David Shapiro noted that there were two types of Rand Hedges, those that exported and had South African costs and those that were listed in South Africa but operated overseas with no link to South Africa except through their listing. This is the same distinction made by Barr and Kantor (2005) as they distinguished between Rand Leverage shares and Rand Hedges. This point was reiterated by Julius Cobbett on the Moneyweb website on 16 June 2006 when he pointed to how much better the ITRIX performed than other “Rand Hedges” when the Rand depreciated as the ITRIX is based entirely overseas.

3.2 Rand Hedge diversification

The second point of “Resources stocks act as Rand Hedges”, that of the need to diversify Rand Hedges, is a common theme in the domestic press. In an article in Fin Week titled “Buy Satrix as a hedge”, Vic de Klerk proposed that Rand Hedging was not as popular as seen previously. He attributed this to increased volatility in commodity prices relative to the volatility in the exchange rate, implying that the price of the commodity for sale dominated the exchange rate effect. Thus the companies that de Klerk viewed as Rand Hedges, which were exporting, typically resource, companies, were more sensitive to the price of their export in dollars than to the exchange rate. de Klerk also pointed to the forward selling of gold as a factor that reduced the ability of gold companies to be considered as Rand Hedges. Although de Klerk’s argument only holds when the exchange rate is stable, his point that Rand Hedges have other exposures is valid. He points to the heavy weighting of Rand Hedges in the Top40 Index and thus proposes that the best Rand Hedge is to simply invest in the SATRlX40. The correlation between the Top40 and the R/S exchange rate will be investigated in later chapters.

Other commentators have also pointed out that Rand Hedges typically have exposures other than the exchange rate. “Return of the Rand Hedge Shares” on the
Moneyweb website by Julius Cobbett noted that Rand Hedging is not necessarily a simple procedure as shares inevitably have other exposures such as to the gold price. This idea was repeated in an article on 3 June 2006 on the Moneyweb website wherein Erika van der Merwe pointed to comments by investment managers who cautioned against investing in resource shares as Rand Hedges alone as they were also exposed to commodity prices. In addition it was pointed out that some JSE-listed companies that operate overseas benefit from Euro strength or weakness relative to the Dollar adding another level of complication to picking Rand Hedge stocks. On 9 May 2005 Alec Hogg provided a list of 10 Rand Hedges on the Moneyweb website. He pointed out that some shares that were typically cast as Rand Hedges did not quite fit their categorisation and listed Liberty international, Richemont, SteinHoff, Anglo American and BHP Billiton as examples. His argument was that although these shares increased in value in response to a Rand depreciation recently they had not decreased in value in response to Rand strength. This is possibly due to the points mentioned earlier, that of Rand Hedges having exposure to other factors such as the gold price or the property market in England. Of the shares listed as hedges only Goldfields, Anglogold Ashanti, Anglo Platinum, Impala and Sappi are constituents of the Top40. The correlation between these, and other, constituents of the Top40 against the R/$ exchange rate will be investigated in further chapters. In September 2004 a Moneyweb article pointed to David Mohr suggesting that it was the time to start investing in Rand Hedges with the caveat that commodity prices may weaken highlighting the other exposures that Rand Hedges may have.

### 3.3 Usefulness of Rand Hedges

Parallel to the issue of selecting Rand Hedges is determining if Rand Hedges are even required. During the recent period of Rand strength hedging against Rand weakness received less attention than it had previously and if the currency remains
stable (or matches its P.P.P. movements) there is no need for it. There is however a
large number of articles predicting future volatility in the Rand and possible
weakening of the exchange rate. The main reasons given for future weakening of the
Rand are the large deficit on the Balance of Payments (B.O.P.) and the effect foreign
investors will have if they begin to view emerging markets negatively.

Howard Preece raised the issue of anticipating the next stage of decline of the Rand
in an article titled “When the Rand goes south again” in Fin Week in January 2005.
He pointed out that with the rising B.O.P. deficit it was inevitable that the exchange
rate will come under pressure at some point. The main concern is that foreign
investments have been funding the trade deficit and if emerging market sentiment
turns negative this funding will decrease and put pressure on the Rand to depreciate.
In an article titled “Wobbles of an Imbalanced World tip fund SA’s way” in the
Financial Mail in March 2006 the increasing attention that the J.S.E. was receiving
from foreign investors was noted. It was pointed out that the J.S.E. had attracted
R51bn Rand of investment from foreigners in 2005, up from R32bn in 2004. It was
also pointed out that it was possible for this trend to reverse as it had done in 1998.
In an article titled “Honeymoon is over” in Fin Week in August 2006 Greta Steyn
pointed that foreigners were net sellers of shares on the J.S.E. in the first three weeks
of July 2006. This would place pressure on the Rand as foreign portfolio investment
in South Africa was helping to mitigate the large trade imbalance. In an article on
Moneyweb on 31 August 2006 titled “Tourists, bloody tourists” Barry Sergeant
pointed to reports showing that foreign investors were beginning to pull out of the
J.S.E. in a change from 2005 in response to the large current account deficit. An
article titled “Rumbles over the Rand” in Fin week in April 2005 added to the
predictions of a future weakening of the Rand by pointing to the increasing deficit
on the B.O.P. In “Playing it safe” in Fin Week in July 2006 Lucas de Lange
suggested that the days of Rand strength were over and that Exchange Traded
Funds, specifically ITRIX, NewRand, DJ Euro stoxx 50 and NewGold would
provide protection against a depreciating currency. An article on 18 August 2006 in
Chapter 3: Informal literature review

Business Day titled “Get used to Rand’s ups and downs” points to the increasing volatility and possible depreciation that can be expected for the Rand due to the large current account deficit. An article in the Business Report on 17 January 2006 suggested that a spurt of Rand strength had led investors to sell shares that had a foreign component. On 24 April 2006 an article in the Business Report titled “Foreigners are selling equities and piling back” questioned whether foreign investors were beginning to pull out of the J.S.E. and the extra pressure that this could put on the J.S.E. This would suggest that Rand Hedging would again become an important aspect of investing on the J.S.E.

3.4 Conclusions

The most important points that one can draw from the domestic financial press is that firstly a share’s potential for being a “Rand Hedge” is largely determined by the industry in which the company operates. A typical example is the numerous references to resource share being labelled “Rand Hedges”. This classification may be roughly accurate but it only focuses on one side of a company’s activities i.e. Sales, it ignores whether a company may have inputs that are imported and negate the advantage that a company may receive from a Rand depreciation. This form of classification also largely ignores the efforts that an individual company may expend in reducing their exposure to the exchange rate. Due to this lack of rigour in determining the true relationship that companies may have with the exchange rate there are some discrepancies with regard to classifying specific shares. In addition to this there is little mention of the size of a “Rand Hedge” effect, with a few exceptions, but rather that it simply exists. These deficiencies may be a function of several variables including the financial sophistication of the target market of the specific media company. Given these deficiencies there is still a great deal of attention placed on the R/$ exchange rate and it is not necessarily the place for scientific rigour.
Secondly, even with the deficiencies that the domestic media has, the concept of shares reacting to the exchange rate is better developed in the press than in the local formal literature. The idea of mitigating exposure to the exchange rate by using strategic allocation in a equities frame work is hardly discussed at all in the formal literature, while it nearly dominates the discussion on portfolios in the media when the volatility of the R/$ exchange rate rises. This may be a result of the difference between statistical and economic significance. While statistical significance may be the determinant of a relationship between two variables in the formal media, the domestic press is more concerned with economic significance, thus even though some shares may not have significant R/$ coefficients and thus might elude being classified as hedges in the formal literature, they may have positive R/$ coefficients and thus be classified as hedges in the domestic press. This point may explain both the exposure that investing with regard to the exchange rate gets in the domestic press and the lack of exposure the concept has within the formal press. The general view within the informal literature is that the ability to classify shares as Rand Hedges still has value as the Rand is about to enter a more volatile period.
Chapter 4: Model Specification

Most of the literature follows the model of Jorion (1990), that of regressing share or portfolio returns on a term for the market and a term for the exchange rate. As seen in the literature review there is still scope for variation within this specification, as there are a multitude of lags and definitions of exchange rates that could be applicable. This chapter investigates appropriate formulae for calculating returns, terms for the exchange rate and terms for the market.

For the remaining chapters returns are defined as annualised log returns. Share and index returns are adjusted for dividends using the same methodology Datastream uses when the timing of Dividends is unknown. Thus monthly returns on share i are calculated using equation (4.1)

\[ r_{i,t} = 1200 \times (\ln \left( \frac{P_{i,t}}{P_{i,t-1}} + \frac{DY_{i,t}}{1200} \right) ) \]  

(4.1)

Where

- \( r_{i,t} \) is the return of share i at time t
- \( P_{i,t} \) is the price of share i at time t
- \( DY_{i,t} \) is the dividend yield at time t

Multiplying the log returns by 1200 has the effect of annualising the monthly returns to allow for easier interpretation but does not affect the coefficients of later regressions.
Following Barr and Kantor (2005) it was decided to restrict the study to the consistent constituents of the Top40 Index over the past few years. This implies that the share returns investigated were restricted to those belonging to AGL, AMS, ANG, ASA, BAW, BIL, BVT, ECO, FSR, GFI, HAR, MLA, IMP, INL, INP, IPL, KMB, LBT, LGL, MTN, NED, NPK, NPN, NTC, OML, PIK, PPC, RCH, REM, RMH, SAB, SAP, SBK, SHF, SLM, SOL, TBS, TKG, VNF and WHL all of whom are listed on the Johannesburg Stock Exchange.

The monthly returns on the exchange rate were calculated using equation (4.2).

\[ R/S_t = 1200 \times (\ln \left( \frac{P_{e,t}}{P_{e,t-1}} \right)) \]  \hspace{1cm} (4.2)

Where

- \( R/S_t \) is the return of the R/$ exchange rate at time \( t \)
- \( P_{e,t} \) is the Rand price of the specified exchange rate

Specifying \( P_{e,t} \) as the Rand price of the specified exchange rate implies that Rand depreciations will be reflected as positive returns and Rand appreciations will be reflected as negative returns. This allows the sign of each share’s exposure to be comparable to that determined by Barr and Kantor (2005).

Returns were also calculated using a 12-month lag as an alternative to monthly returns following Chow et al. (1997). These overlapping returns were calculated using equation (4.3)

\[ r_{t,t-12} = (\ln \left( \frac{P_{e,t}}{P_{e,t-12}} + DY_{t,t} \right)) \]  \hspace{1cm} (4.3)
The exchange rate returns were calculated using (4.4)

\[ \frac{R}{S_t} = (\ln \left( \frac{P_{e,t}}{P_{e,t-12}} \right) ) \]  

(4.4)

In addition to the two possible lags (annual and monthly) used to calculate returns, there are three possible exchange rates. Following the literature the Nominal, Real Effective and Nominal Effective exchange rates are investigated.

It is possible that there will be contemporaneous correlation between the residuals of the returns after the term for the market and the term for the exchange rate has been fitted. To investigate this, another model is fitted with more terms allowing for world and emerging market sentiment following Benson and Faff (2003).

This gives the two models investigated as:

\[ r_{t,d} = \alpha_d + b_1 R/S_t + b_2 Top40_t + \epsilon_{t,d} \]  

(4.5)

\[ r_{t,d} = \alpha_d + b_1 R/S_t + b_2 Top40_t + b_3 EMI_t + b_4 MSCI_t \]  

(4.6)

Where

- \( MSCI_t \) is the return on the Morgan Stanley Composite Index at time \( t \), representing a world index movement.
- \( EMI_t \) is the return on the DataStream Emerging Market Index at time \( t \), orthogonalised against \( MSCI_t \).
- \( Top40_t \) is the return on the Top40 Index at time \( t \), orthogonalised relative to the EMI series and the MSCI series.
Equation (4.5) is similar to the model specified by Jorion in 1990 that is widely used throughout the literature. Equation (4.6) is an attempt to remove contemporaneous correlation between the residuals of equation (4.5) and thus investigate if there is a missing variable bias. The exogenous variables are orthogonalised to ensure that they are independent and the regression coefficients are not subject to multicollinearity.

In addition to the above models the validity of a lagged exchange rate was investigated following Chow et al. (1997). Largely following their specification share returns were related to the contemporaneous exchange rate innovation, the exchange rate innovation lagged by one month and the contemporaneous return of the Top40 Index through equation (4.7)

\[ r_{t,j} = a_j + b_1 R/S_t + b_2 R/S_{t-1} + b_3 \text{Top}40_t + e_{t,j} \] (4.7)

Each of the models was run over the period from January 1999 to June 2006 and the results are discussed in the next subsections. Throughout the literature the measure of success of a model is measured by the number of shares that are found with significant exchange rate exposure relative to a different model. This convention is followed in this thesis.

### 4.1 Type of exchange rate

The first variation on Jorion’s model investigated was the type of exchange rate to use in equation (4.4) and hence equation (4.5). The literature has pointed to the problems associated with using a trade-weighted exchange rate, that of lowered
exposure, and also the similarity between Real and Nominal exchange rates. The Nominal effective exchange rate, the Nominal bilateral R/$ exchange rate and the Real Effective R/$ exchange rate were compared in the following correlation matrix using returns from January 1999 to June 2006.

<table>
<thead>
<tr>
<th></th>
<th>Nominal RS</th>
<th>Nominal Effective</th>
<th>Real Effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal RS</td>
<td>1.0000</td>
<td>0.8584</td>
<td>0.9353</td>
</tr>
<tr>
<td>Nominal Effective</td>
<td>0.8584</td>
<td>1.0000</td>
<td>0.8530</td>
</tr>
<tr>
<td>Real Effective</td>
<td>0.9353</td>
<td>0.8530</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Table 4.1 Correlation between three South African exchange rates

The U.S. Dollar was selected as the bilateral exchange rate as most international commodities, including oil and gold, are priced in U.S. dollars. In addition, the Dollar acts as the base currency to which other currencies are compared. Even though Europe is South Africa’s largest trading partner most of the focus on the exchange rate in the domestic press is aimed at the R/$ exchange rate. The correlation between the exchange rates is quite high and thus one would not expect there to be much difference between the regression coefficients of equation (4.4) for each of the exchange rates. In order to allow the comparison of coefficients it was necessary to scale the Real and Effective exchange rates to the Nominal exchange rate and January 1999 was chosen as the base date.

After running the regressions it was found that 23 of the shares had significant exposure at the 5% level to the Nominal R/$ exchange rate. When the effective exchange rate was used 16 shares had significant exposure at the 5% level and these 16 were a subset of the 23 shares found using the bilateral exchange rate. Only 5 of the shares were significantly exposed to the nominal exchange rate at the 5% level and these 5 were a subset of the 16 exposed to the Real effective exchange rate. Comparing the number of shares with significant exposure to the exchange rate for a given significance level could be subject to criticism as the significance level chosen...
is arbitrary. With this in mind the ranking with respect to the number of shares with significant exchange rate exposure was examined for each significance level, starting with 1% and incrementing by 1% up until 30%, was examined. For each of the significance levels examined the Nominal R/S exchange rate had the highest number of shares with significant exposure, followed by the Real effective exchange rate and then the Nominal effective exchange rate. The fact that this ranking was consistent for every significance level examined implies that one can say with a fair degree of certainty that there are more shares in the Top40 that are exposed to the bilateral R/S exchange rate than to either of the effective exchange rates. This confirms the results shown by Benson and Faff (2003), Di Iorio and Faff (2001) and Dominguez and Tesar (2001) who demonstrated that there is more widespread exposure to certain bilateral exchange rates than trade weighted exchange rates.

Given the difference between the exchange rates, and following the literature, the nominal bilateral R/S exchange rate was decided to represent the exchange rate term in (4.4). This avoided the downward bias in exchange rate exposure associated with the trade-weighted exchange rate and the difficulty in interpretation of the real exchange rate.

4.2 Return Horizon

The next step was to decide on the lag for calculating the returns in the series. As mentioned above there were two options to select from; monthly or annual returns. The problem with monthly returns is the susceptibility to periods when the shares go ex-dividend. This would show a decrease in the share price that would not have been related to the exchange rate or the Top40 Index. To get around this problem a dividend yield term was added that would increase when the share depreciated and thus negate the ex-dividend problem to some degree. This correction is not perfect and thus the t-statistics of any exposure found would be biased towards zero as it is
unlikely that exchange rate movements or Top40 movements would consistently coincide with the ex-dividend decreases, which would be needed to keep the t-statistic at its true value or increase it. Another possible correction is to use annual returns as the ex dividend decreases would be irrelevant, assuming that dividends are declared at the same time each year and that they are fairly consistent in size. The problem with annual returns is that they overlap and thus induce autocorrelation in the returns. The most common method of correcting for induced autocorrelation is the Newey-West procedure devised by Newey and West (1987) to be able to adjust t-statistics to account for induced autocorrelation.

Evaluating equation (4.5) using annual returns and applying the Newey-West procedure in Eviews gave 27 shares with exchange rate exposure that was significant at the 5% level out of 40. Evaluating Equation (4.5) using monthly returns gave 23 shares with significant exposure. The 27 shares found using monthly data included 20 of the 23 found using monthly data. Most of the literature uses monthly returns and given that annual returns do not find that many more significantly exposed firms (and some firms lose their significant exposure), monthly returns will be used in this thesis as well.

4.3 Including exposure to world sentiment

The purpose of including the terms for the World market and Emerging market is to investigate if the simple model proposed by Jorion needs extra terms to remove contemporaneous correlation between the residuals of equation (4.5) for each share. If the World term and the EMI term were able to account for some of that contemporaneous correlation one would expect that the adjusted $R^2$ values of equation (4.6) would be higher than the adjusted $R^2$ values for equation (4.5). In fact the average $R^2$ only increased by 4.7% with the addition of the extra variables and it was 32% before. The adjusted $R^2$ increased by 2.4% from 29.9% to 32.3%. The
results from these regressions show that in terms of adjusted $R^2$, at least, the simpler model is acceptable and as such will be used throughout the remaining chapters.

4.4 Including a lagged exchange rate term

The last question addressed in terms of basic model specification is that of a lagged relationship between shares and the exchange rate. It is reasonable to assume that investors react almost instantaneously to changes in the Top40 Index, all that is needed for a contemporaneous relationship in (4.4) is that investors take less than a month to react, which highly plausible, but that assumption needs to be investigated with regards to the exchange rate. Bartov and Bodnar (1994) showed that a lagged relationship exists in Australia due to the relatively short time that the AUD had been floated and that investors had not been able to exactly determine the effect that exchange rate innovations had on profitability yet. This needs to be investigated in the South African context. After estimating equation (4.7) it was found that only 3 shares had significant exposure to the exchange rate lagged by one period. These were Telkom, Edgars and Absa. Each of these shares had significant exposure to the contemporaneous exchange rate. Given the low number of shares that are exposed to the lagged exchange rate it was decided to leave it out of the model.

4.5 Conclusions

The results of this chapter show that it is possible to treat the relationship between the exchange rate and each of the constituents of the Top40 as being contemporaneous in nature, in addition it was found that there was more widespread exposure, as defined by Adler and Dumas (1984), to the nominal R/S exchange rate than to either of the effective exchange rates investigated. Including terms for the
market did not increase the $R^2$ by much and in the interests of parsimony it was decided to leave out the terms for the world and EMI market. It was noted that by increasing the return horizon more firms were found to be exposed to the exchange rate but seeing as the increase was relatively small and that the majority of the literature used monthly returns it was decided to use monthly returns as well, enabling comparison to the international literature. This gives the final model used to link the exchange rate to changes in share prices as:

$$r_{ij} = a_i + b_1 R/S_i + b_2 Top40_i + e_{i,j}$$  \hspace{1cm} (4.7)

where

$R/S_i$ is the innovation in the nominal R/$ exchange rate at time $t$

$Top40_i$ is the innovation in the Top40 Index at time $t$

Returns are measured using a monthly horizon.

This model, and a few slight variations will be used throughout the remaining chapters.
Chapter 5: Categorisation of South African Shares

This chapter is based on a technical report titled “The Effect of the Rand Exchange Rate on the JSE Top40 stocks – an Analysis for the Practitioner” written by Barr, Kantor and Holdsworth (2006).

Barr and Kantor (2005) provided a mechanism for grouping, a priori, constituents of the Top40 Index into three categories based on the denomination of their revenues and costs. These categories were named Rand Hedge, Rand Play and Rand Leverage. A further category is added for those shares that do not fit neatly into any of the three previous categories and is named “Mixed”. In order to examine the effectiveness of the categorisation GARCH adjusted regression is performed over two periods; January 1999 to September 2002 and October 2002 to June 2006, and the t-statistics of the exchange rate coefficients are extracted and ranked. This enables the ability to simultaneously test the effectiveness of the categorisation and the stability of exchange rate exposure. The t-statistics are ranked in order to provide a mechanism for comparing the strength and reliability of exchange rate coefficients to allow for the ability to base a portfolio on future expected Rand movements.

5.1 Categorisation

Rand Hedge companies are based overseas and receive their revenues and incur their costs in a foreign currency, typically U.S. Dollars (USD) and/or British Pounds (GBP). Dividends of these companies are declared in a foreign currency and thus a
depreciation of the exchange rate implies an immediate gain for South African investors, which should push up the J.S.E. price, as prices reflect the present value of future expected Rand earnings. These companies are not linked to the South African economy except for their listing on the J.S.E, typical examples of Rand Hedges are Richemont, which has its primary listing in Switzerland and sells luxury goods internationally, and Liberty Plc, a London listed property share.

Rand Leverage companies receive their revenue in a foreign currency, typically USD and/or GBP while their costs are denominated in Rands. This implies that a depreciation of the Rand beyond that suggested by P.P.P. will result in an immediate profit gain for the company and this should be reflected in an increase in the share price. If the R/$ exchange rate only depreciates at the rate implied by the difference in inflation between South Africa and the U.S. then there is no exchange rate gain for the company as revenue will rise at the same rate as costs. This also implies that as inflation, and specifically labour costs, rise in response to the depreciation, the previous exchange rate gain will be negated. This implies that Rand Leverage firms only benefit in the short term from an exchange rate depreciation if P.P.P. holds. Typical examples of Rand Leverage firms are resource companies such as Goldfields and Harmony.

Rand Play companies are entirely domestically based; they receive their revenues and incur their costs in Rands. Barr and Kantor placed retailers and banks in this group. If a company’s revenues and costs are in Rands, it is not immediately obvious why an exchange rate innovation should affect it. Barr and Kantor hypothesised that Rand play returns should have a negative correlation with the fluctuations in the exchange rate, implying that they benefit from Rand appreciation and suffer from Rand depreciation and ascribed this relationship to foreign investors in the J.S.E. A Rand depreciation implies immediately reduced Dollar dividends for a foreign investor and also increases uncertainty over future Dollar denominated dividends. This is reflected in a lower share price.
Some companies do not fit neatly into any of the above three categories, such as Remgro and Old Mutual. These companies derive income from their South African and overseas operations in roughly equal proportions, allowing their Rand Leverage and Rand Play elements to cancel each other out, giving neutral R/\$ exposure. These companies are categorised as “Mixed”.

Following from Barr and Kantor, the persistent constituents of the Top40 will be used here to allow the study to be useful to investors and avoid problems associated with thin trading, as such the universe of shares examined is the same as in chapter 4. Table 5.2 provides a list of the shares examined and the classification of each share with regards to exchange rate exposure. As an experiment to investigate the appropriateness of the categorisation given by Barr and Kantor (2005), a market cap weighted portfolio of shares was constructed for each of the categories using the constituents mentioned by Barr and Kantor in their paper. The following table gives the exchange rate regression coefficients with the R^2 of each portfolio using equation (4.7) over the same period as Barr and Kantor (2005); Jan 2001- Aug 2003.

### Exchange Rate betas for each Rand category:

<table>
<thead>
<tr>
<th></th>
<th>R/$ b</th>
<th>t-stat</th>
<th>p-value</th>
<th>R^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHI</td>
<td>0.364</td>
<td>2.996</td>
<td>0.006</td>
<td>0.724</td>
</tr>
<tr>
<td>RLI</td>
<td>0.783</td>
<td>8.483</td>
<td>0.000</td>
<td>0.913</td>
</tr>
<tr>
<td>RPI</td>
<td>-0.270</td>
<td>-1.928</td>
<td>0.064</td>
<td>0.542</td>
</tr>
</tbody>
</table>

*Table 5.1: Regression statistics for each categorisation*

Where RHI is a Rand Hedge index, RLI is a Rand Leverage index and RPI is a Rand Play index. Each index is a market-weighted portfolio of the constituents of each respective category.

Table 5.1 shows that not only is the exchange rate coefficient the right sign for each category, it is also highly significant and the exchange rate and the Top40 Index
explain a large amount of the variation in each category. The fact that it is possible to form portfolios with certain exchange rate characteristics and that these characteristics can be predicted \textit{a priori} allows for the possibility of creating portfolios to hedge against possible movements in the exchange rate. This idea will be investigated further in Chapter 6.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|}
\hline
\textbf{Rand Play shares} & \textbf{Rand Leverage shares} \\
Absa & Anglo American \\
Firststrand & AGL \\
Imperial & Anglo Gold \\
Liberty Group & Angolo Platinum \\
MTN & BHP Billiton \\
Nampak & Gold Fields \\
Naspers & Harmony \\
Nedcor & Impala \\
Network Healthcare & Mittal Steel \\
Pick’n Pay & Kumba \\
RMB & Sappi \\
Sanlam & Sasol \\
Standard Bank & SABMiller plc \\
Telkom & Steinheff international \\
Tiger Brands & Liberty international \\
Venfin & Richemont \\
Woolworths & RCH \\
\hline
\end{tabular}
\caption{Categorisation of examined shares}
\end{table}

5.2 Testing the effectiveness of categorisation

5.2.1 Model

Barr and Kantor (2005) showed their categorisation to be accurate in that the exchange rate coefficients of the shares were in general the same sign as that predicted by their category. In this section the consistency of this exposure is...
After examining various other model specifications, which have been addressed in chapter 4, Barr and Kantor (2005) used equation (5.1) to estimate the exchange rate exposure of each of the shares.

\[ r_i = \alpha + \beta_1 R_{it} + \beta_2 R_{wir} \]  

Where

- \( r_i \) is the log return on share \( i \)
- \( R_{it} \) is the log return of the nominal R/$ exchange rate
- \( R_{wir} \) is the log return on the Top40 Index

The model used here will be different to Barr and Kantor’s (2005) model in two respects. Firstly, as discussed in the preface, the movements of the J.S.E. and the R/$ exchange rate have a theoretical link. This link is due to the categorisations mentioned above and the prevalence of foreign investors in the J.S.E. The correlation between the movements of the Top40 Index as a whole and the R/$ exchange rate is not necessarily stable, as it depends on the relative weighting of each of each of the above categories in the index. Nonetheless, a theoretical relationship exists and the presence of multicollinearity between the Top40 term and the R/$ exchange rate should be investigated. The absence of multicollinearity is not a strict assumption of Ordinary Least Squares regression (OLS) but multicollinearity can lead to unstable coefficient estimates and large variances (see, for example, Greene (2003)). The correlation between the Top40 and the R/$ exchange rate was measured for each of the two periods and found to be -0.0108 and 0.3052 for the first and second period respectively. A Fisher z-transformation was used to estimate the significance of the correlation and p-values of 0.94 and 0.04 were found for the first and second period respectively. Even though the correlations are small and
below the heuristic cut-off of 0.7, the second value was significant and thus the Top40 Index was orthogonalised relative to the R/$ exchange rate using a side regression. A model where the exchange rate was orthogonalised relative to the Top40 Index was investigated as well. It must be noted that the orthogonalised models were only investigated as possible alternatives and orthogonalisation was not strictly necessary.

Orthogonalisation is a method of avoiding the problems associated with multicollinearity and is widely used in the literature (see, for example, Benson & Faff (2003:101), Liang and Mougoué (1996), Choi & Prasad (1995:78) and Jorion (1991:366), who orthogonalised the exchange rate term variable with respect to the overall market.). Following the literature, the exchange rate term was orthogonalised relative to the Top40 Index, and to allow for isolating the exposure to the entire exchange rate movement a model that orthogonalised the Top40 Index relative to the exchange rate was also examined. Given the low correlation between the exchange rate and the Top40 Index it was not surprising that the coefficients and t-statistics for both of the orthogonalised models and the unorthogonalised model were similar. Given the similarity of the t-statistics and that orthogonalising the exogenous variables can lead to biases estimates (see, for example, Giliberto (1985)), only the unorthogonalised results are reported here.

The second difference between the models used in this chapter and (5.1) was the inclusion of GARCH(1,1) terms. Di Iorio & Faff (2001) fitted terms for the market return, exchange rate return and the lagged exchange rate return to Australian share returns and fitted GARCH(1,1) terms to control for conditional heteroskedasticity in the residuals. Di Iorio & Faff found the GARCH terms to be significant in all cases. Di Iorio and Faff were, however, using daily data where the presence of volatility clustering is more apparent. This chapter uses monthly data but it was decided to add GARCH (1,1) terms to control for the possibility of conditional heteroskedasticity.
Chapter 5: Categorisation of South African Shares

The GARCH model used is of the form:

\[ \sigma_i^2 = \omega_0 + \omega_1 \epsilon_{i,t-1}^2 + \omega_2 \sigma_{i,t-1}^2 \]

where:

- \( \sigma_i^2 \) - variance of the residual for share \( i \) at time \( t \),
- \( \epsilon_i \) - is assumed to have zero expectation, be homoscedastic and independent over time.

5.2.2 Results

The GARCH adjusted models were run over the two periods February 1999 to September 2002 and October 2002 to June 2006. The time periods were chosen to split the available data into the two largest equally sized sub samples that avoided the emerging market crisis in 1998. The results of the regression are displayed in tables 5.3 and 5.4, which give the values for the coefficients, their respective t-statistics and the \( R^2 \) of each regression.

Confirming Barr and Kantor's (2005) results, there is a large degree of congruence between the \( a \ priori \) sign of the R/$ term, based on the categorisation of each share, and the estimated coefficient. The only Rand Hedge shares to have negative signs in the first period are ANG, GFI, HAR and RCH. The second period produced a few more negative coefficients; these belonged to ANG, GFI, MLA, INP and SAP. Negative or low positive coefficients of hedge companies can be a reflection of companies' ability to hedge exposure or mitigate exposure by importing equipment as pointed out by Bartov and Bodnar (1994). As referred to in the informal literature.
review, South African gold companies are prone to hedging exposure to fluctuations in the gold price by selling contracts to sell gold at a fixed dollar price at a later stage. If the Dollar gold price remains stable, and the Rand depreciates, this acts as a hedge against Rand depreciation. INP can be expected to have a low exposure to the exchange rate due to the relatively large portion of Investec’s profits that are still sourced in South Africa. The low exposure of Mittal could be due import parity pricing for steel. As the Rand depreciates, steel becomes more expensive in Rand terms, which will reduce demand. Thus even though Mittal is able to charge Dollar prices, the fact that they sell to the South African market negates this and removes the exchange rate exposure of Mittal. There may well be other more subtle effects at play, but as long as they are consistent their specification is irrelevant in terms of ranking the ability of hedge shares to benefit from a Rand depreciation.

The level of agreement between the *a priori* sign of exposure and the empirical value is even higher for the Rand play companies than it was for the Rand Hedge companies. The only Rand plays to have positive exposure in the first period were NTC and SLM. These returned to their expected sign in the second period, where the only positive exposure belonged to VNF, possibly as a result of Vodacom’s increasing expansion out of South Africa as well as the rapid share appreciation before the sale of the company to Vodafone.

The $R^2$ values for each of the equations are encouragingly high as are the t-statistics of the Top40 term, giving credence to the model specification and the inclusion of a market term.

The consistency of the sign of exchange rate suggests that exchange rate exposure is not as unstable as suggested in the literature.
<table>
<thead>
<tr>
<th>Leverage/Hedge</th>
<th>Jan 99-Sept 02</th>
<th>Oct 02-June 06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R/$ B</td>
<td>R/$ t</td>
</tr>
<tr>
<td>AGL</td>
<td>0.8194</td>
<td>3.294</td>
</tr>
<tr>
<td>AMS</td>
<td>0.2285</td>
<td>0.369</td>
</tr>
<tr>
<td>ANG</td>
<td>-0.5069</td>
<td>-1.661</td>
</tr>
<tr>
<td>BIL</td>
<td>0.6457</td>
<td>2.395</td>
</tr>
<tr>
<td>GFI</td>
<td>-0.3226</td>
<td>-0.802</td>
</tr>
<tr>
<td>HAR</td>
<td>-0.1192</td>
<td>-0.261</td>
</tr>
<tr>
<td>KMB</td>
<td>1.149</td>
<td>1.041</td>
</tr>
<tr>
<td>MLA</td>
<td>0.4136</td>
<td>0.783</td>
</tr>
<tr>
<td>IMP</td>
<td>-0.0535</td>
<td>-0.182</td>
</tr>
<tr>
<td>INP</td>
<td>0.1479</td>
<td>0.603</td>
</tr>
<tr>
<td>LBT</td>
<td>0.5281</td>
<td>1.988</td>
</tr>
<tr>
<td>RCH</td>
<td>-0.0357</td>
<td>-0.182</td>
</tr>
<tr>
<td>SAP</td>
<td>0.286</td>
<td>1.122</td>
</tr>
<tr>
<td>SOL</td>
<td>0.2238</td>
<td>0.656</td>
</tr>
<tr>
<td>Mixed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BAW</td>
<td>-0.4817</td>
<td>2.783</td>
</tr>
<tr>
<td>BVT</td>
<td>-0.4909</td>
<td>2.233</td>
</tr>
<tr>
<td>INL</td>
<td>-0.818</td>
<td>4.135</td>
</tr>
<tr>
<td>OML</td>
<td>-0.3322</td>
<td>-1.437</td>
</tr>
<tr>
<td>REM</td>
<td>-0.1025</td>
<td>-0.384</td>
</tr>
<tr>
<td>SAB</td>
<td>0.286</td>
<td>1.122</td>
</tr>
<tr>
<td>SHF</td>
<td>0.3097</td>
<td>1.354</td>
</tr>
</tbody>
</table>

Table 5.3 Regression coefficients for Rand leverage, hedge and mixed shares
### Table 5.4 Regression coefficient of Rand Plays

<table>
<thead>
<tr>
<th>Play</th>
<th>Jan 99-Sept 02</th>
<th>Oct 02-June 06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R/S B</td>
<td>R/S t</td>
</tr>
<tr>
<td>ASA</td>
<td>-0.4007</td>
<td>-0.829</td>
</tr>
<tr>
<td>ECO</td>
<td>-1.2403</td>
<td>-3.068</td>
</tr>
<tr>
<td>FSR</td>
<td>-0.272</td>
<td>-0.996</td>
</tr>
<tr>
<td>IPL</td>
<td>-0.7003</td>
<td>-2.894</td>
</tr>
<tr>
<td>LGL</td>
<td>-0.2754</td>
<td>-0.658</td>
</tr>
<tr>
<td>MTN</td>
<td>-0.7566</td>
<td>-1.479</td>
</tr>
<tr>
<td>NED</td>
<td>-0.6657</td>
<td>-2.21</td>
</tr>
<tr>
<td>NPK</td>
<td>-0.9824</td>
<td>-1.768</td>
</tr>
<tr>
<td>NPN</td>
<td>-1.5465</td>
<td>-1.687</td>
</tr>
<tr>
<td>NTC</td>
<td>0.1064</td>
<td>0.227</td>
</tr>
<tr>
<td>PIK</td>
<td>-0.654</td>
<td>-1.766</td>
</tr>
<tr>
<td>PPC</td>
<td>-0.0928</td>
<td>-0.463</td>
</tr>
<tr>
<td>RMH</td>
<td>-0.3927</td>
<td>-1.46</td>
</tr>
<tr>
<td>SBK</td>
<td>-0.2447</td>
<td>-0.949</td>
</tr>
<tr>
<td>SLM</td>
<td>0.0448</td>
<td>0.143</td>
</tr>
<tr>
<td>TBS</td>
<td>-0.6278</td>
<td>-1.798</td>
</tr>
<tr>
<td>TKG</td>
<td>0.1039</td>
<td>0.314</td>
</tr>
<tr>
<td>VNF</td>
<td>-0.7153</td>
<td>-0.383</td>
</tr>
<tr>
<td>WHL</td>
<td>-0.448</td>
<td>-0.84</td>
</tr>
</tbody>
</table>
Examining the ranking of the firms in their ability to hedge against exchange rate exposure provides an interesting point. Each share is ranked according to the t-statistic of the exchange rate coefficient and in the spirit of Ziliak and McCloskey (2004) no attention is placed on an arbitrary level of significance. The only objective is to rank the exposure coefficients, adjusted for their standard error, and examine if this ranking is consistent. Figures 5.1 to 5.3 provide the graphical representation of tables 5.3 and 5.3.

The graphs make it easier to see that not only has exposure followed the sign suggested by the categorisation of each share but that the categorisations have become even more accurate recently as most of the hedges’ exposure became more reliably positive and most of the plays’ exposure became more reliably negative.

Figure 5.1 shows that the most reliable hedges have been AGL, BHP and LBT. AGL has benefited from the recent surge in commodity prices and BHP has similarly benefited from the recent high oil prices. LBT trades in London as a property share. These are three entirely different companies and thus simultaneously investing in them would give a degree of diversification as well as protection against Rand depreciation.

Figure 5.2 shows that IPL has been the most effective Rand Play followed by the banks and retailers. The ranking within the retailers and banks has been relatively consistent as evidenced by the number of parallel lines and that there are only four lines that cut through more than six lines which would imply a large change in ranking.

Figure 5.3 shows how Old Mutual has become more of a hedge as its overseas components contribute more to its profit line, the same can be said for Investec. This provides clear evidence for the effect of foreign operations on exchange rate exposure.
Chapter 5: Categorisation of South African Shares

**Figure 5.1 Movement of R/$ coefficients of Leverage and Hedge shares**

- AGL
- AMS
- ANG
- BIL
- GFI
- HAR
- KMB
- MLA
- LBT
- RCH
- SAP
- SOL
- HAR
- ANG
- MLA

01/99-09/02 10/02-06/06
Chapter 5: Categorisation of South African Shares

Figure 5.2 Movement of R/$ coefficients of Rand Plays
Chapter 5: Categorisation of South African Shares

Figure 5.3 Movement of R$ coefficients of Mixed shares
5.3 Conclusions

From the results presented above it is clear that not only is Barr and Kantor’s (2005) classification effective in grouping homogenous shares with respect to their exchange rate exposure but it has in fact become more accurate over the past few years. In addition it was found that exchange rate exposure is stable within each group and that ranking the t-statistics of the exchange rate exposure yields a few shares that are consistently exposed in one direction. This should be useful in portfolio construction with regards to controlling exchange rate exposure.

Displaying the movement in the exchange rate exposure revealed the link between foreign operations and exchange rate exposure, as those firms that expanded overseas faster than they did domestically increased their exposure. This provides confirmation of Jorion’s (1990) hypothesis that the level of exposure of a company is related to the level of foreign sales of that company.
Chapter 6: Hedging against R$/S depreciation

The previous chapters have shown that each company has a different exposure to the exchange rate, which is largely determined by the denomination of the company’s income and expenses. This chapter examines two methods of using this information to construct portfolios that benefit from exchange rate depreciation and hence act as Rand Hedges. Two different portfolio construction techniques utilising portfolio optimisation were examined and compared to ITRIX 100, an Exchange Traded Fund (ETF), in their ability to hedge against a depreciation in the R$/S exchange rate. The optimised portfolios were constructed using rolling windows with four and a half years of monthly data from January 1999 to June 2005. The models were re-estimated annually each July using the previous four and a half years of monthly data. All of the portfolios were compared over 12 month periods from July 2003 to June 2006, both for the entire 12 months and for subsections of the 12 months.

There is a dearth of South African formal literature focusing on creating portfolios to handle the effects of a volatile currency by investing in the equity market alone. Most forms of hedging exposure to the exchange rate focus on holding currency positions in the market, and it is the purpose of this chapter to show that it is possible to avoid the expense and complication involved in this process by selecting and investing in particular shares with regard to their exposure to the exchange rate.

6.1 Nomenclature

The focus of this chapter is the implementation of a methodology to hedge against a depreciation in the exchange rate against the dollar by investing locally, specifically
Chapter 6: Hedging against R/$ depreciation

in the JSE, and hence the problem is one of portfolio selection. Given the focus on the exchange rate, aside from the market, it was necessary to include a term for the R/$ exchange rate when modelling share returns.

Following Barr and Kantor (2005), this chapter relies on regressing the log returns of each of the constituents of the Top40 against the log returns of the Top40 Index and R/$ exchange rate. In order to avoid the problems associated with multicollinearity, the Top40 term is orthogonalised relative to the R/$ exchange rate. Although the absence of multicollinearity is not a strict assumption of Ordinary Least Squares regression, multicollinearity can lead to instability in coefficients, with higher associated variances. Instability of the R/$ \beta$ would be a particular problem in this instance as different periods are used to form estimates of the coefficients and instability due to multicollinearity could make it very difficult to examine the consistency of exchange rate exposure. The relationship between the Top40 Index and the exchange rate can be represented as:

\[ R_{40t} = \gamma_0 + \gamma_1 R_{s} + c_t \]  

(6.1)

Where

- $R_s$ is the log return of the R/$ exchange rate at time $t$
- $R_{40t}$ is the log return of the Top40 Index at time $t$

Regressing the Top40 onto the exchange rate gives:

\[ \hat{R}_{40t} = \hat{\gamma}_0 + \hat{\gamma}_1 R_s \]  

(6.2)

$R_{40t} - \hat{R}_{40t}$, denoted as $R'_{40t}$, is orthogonal to the exchange rate and represents the
fluctuations in the Top40 not explained by the exchange rate.

This allows the log return on each share $i$ to be related to the movements of the exchange rate and the Top40 in the following manner:

$$R_t = \alpha_i + b_{1i} R_{S_t} + b_{2i} R'_{40t} + \epsilon_t$$  \hspace{1cm} (6.3)

Where

$R_t$ is the log return of share $i$ at time $t$

This is a two-index model, where “index” simply implies “term” and is not an indication of actual indices being used, and is subject to the following conditions, as shown in Elton, Gruber, Brown and Goetzmann (2000) and Sharpe (1970)

1) corr($\epsilon_{it}, \epsilon_{jt}$) = 0  $\forall i \neq j$
2) corr($R_{St}, \epsilon_{it}$) = 0  $\forall i$
3) corr($R'_{40t}, \epsilon_{it}$) = 0  $\forall i$
4) corr($R_{S_t}, R'_{40t}$) = 0  $\forall i \neq j$

This is very close to a prespecified, two-index APT model. However, the methods used in this chapter do not require the pricing of exchange rate exposure or the pricing of the Top40. All that is required is the ability to, a priori, select hedge shares, which Barr and Kantor (2005) have shown to be possible, and thus the pricing factors are not estimated.

For any given portfolio where share $i$ constitutes (100*wt)% of the portfolio, the following equation relates the log return of the portfolio to the log returns of the exchange rate and the orthogonalised Top40.
Chapter 6: Hedging against R/S depreciation

\[ R_{pt} = \alpha_p + b_{p1} R_{st} + b_{p2} R'_{40t} + e_{pt} \]  \hspace{1cm} (6.4)

Where

- \( R_{pt} \) is the log return of portfolio \( p \) at time \( t \)
- \( \alpha_p = \sum_i w_i \alpha_i \)
- \( b_{p1} = \sum_i w_i b_{i1} \)
- \( b_{p2} = \sum_i w_i b_{i2} \)
- \( \sum_i w_i = 1 \)

The variance of portfolio \( p \) is given by:

\[ \sigma_p^2 = \sum_i w_i \sum_i w_j \sigma_{ij} \]

Where

- \( w \) is the vector of weights associated with portfolio \( p \)
- \( \sum \) is the covariance matrix of the log returns of the shares.

Equation (6.1) is estimated using Ordinary Least Squares regression for each share \( i \). This gives:

\[ \hat{R}_{it} = \tilde{\alpha}_i + \tilde{b}_{i1} R_{st} + \tilde{b}_{i2} R'_{40t} \]
Chapter 6: Hedging against R/$ depreciation

The estimated return on portfolio $p$ can then be expressed as:

$$\hat{R}_{pt} = \tilde{\alpha}_p + \tilde{b}_{p1}\tilde{R}_{s1t} + \tilde{b}_{p2}\tilde{R}'_{40t} \tag{6.5}$$

Where

$$\tilde{\alpha}_p = \sum_i w_i \tilde{\alpha}_i$$

$$\tilde{b}_{p1} = \sum_i w_i \tilde{b}_{i1}$$

$$\tilde{b}_{p2} = \sum_i w_i \tilde{b}_{i2}$$

$$\sum_i w_i = 1$$

The expected return of portfolio $p$ is:

$$\bar{R}_{pt} = \bar{\alpha}_p + \bar{b}_{p1}\bar{R}_{s1t} + \bar{b}_{p2}\bar{R}'_{40t} \tag{6.6}$$

Where

$\bar{R}_u$ is the expected log return of share $i$ at time $t$

$\bar{R}_{s1t}$ is the expected log return of the R/$ exchange rate at time $t$

$\bar{R}'_{40t}$ is the expected log return of the orthogonalised Top40 Index at time $t$

Elton, Gruber, Brown and Goetzmann (2000) have provided a summary of the research conducted both in using Indices formed from shares and using fundamental factors in multi index models. One of the more important papers they reviewed was by Chen, Roll and Ross (1986) who introduced a set of non-equity factors to explain share price movement. Their model was successful in that they found certain factors
to be significant, showing that factors affecting the future income of the firm have an effect on the returns in the share price. Others have examined forming indices of companies to act as factors but the results in this field have been mixed with no clear dominance of multi-factor models over single-index models, this was clearly shown by Elton Gruber (1973) who found the single index model to be better at predictions as the multi-index model introduced too much noise. Elton et al. (2000) concluded that while multi-index models have convenient simplification properties, more research needs to be completed before multi-index models will be able to dominate simpler models.

6.2 Data

Following Barr and Kantor (2005) and in the interests of liquidity and allowing the portfolios to be applicable to the investment community, the universe of shares available for the portfolios was restricted to the consistent constituents of the Top40 over the past few years. It was decided to set a minimum number of available entries for the estimation of the portfolios at 30 to prevent short-term movements dictating the constituents of the portfolio. This constraint eliminated the possibility of certain shares being placed in the portfolios, due to their date of listing disallowing 30 points in the time period. This meant that Telkom was excluded from the study.

The ITRIX 100 was chosen to provide a benchmark to compare the effectiveness of the Rand Hedges. The ITRIX 100, owned by the JSE, Deutsche Securities and Sanlam, is effectively an index of the 100 largest stocks listed on the London Stock exchange (LSE). It was listed in South Africa very recently, October 2005, and in order to have sufficient data points to analyse it, its performance was simulated. This was achieved by taking the prices for the FTSE 100 and multiplying them by the Rand/Pound exchange rate. This allowed sufficient points for the test period.
Chapter 6: Hedging against R/S depreciation

6.3 Methodology

Given the literature on Multi-index models it was decided to use a two-index model to estimate the return generating process of the portfolios. The two indices included were the return of the R/S exchange rate and the return of the Top40 Index. The reason for this specification was that it allowed for an expectation of the movement of the exchange rate to have an impact on the expected return of a portfolio. This specification was also consistent with the literature regarding exchange rate exposure. As mentioned above, a required assumption for index models is that the indices have to be independent. The correlation between the returns in the R/S exchange rate and the Top40 for the first, second and third estimation period was 0.25, 0.28 and 0.38 respectively. The significance of these values was investigated using the Fisher z-transformation and the p-values against a two-sided alternative were 16%, 12% and 2% respectively. Given the fact that the correlation was relatively consistent and sometimes significant it was decided to orthogonalise the two independent variables. This is also common in the literature for example, Benson & Faff (2003), Youguo & Mbodja (1996), Choi & Prasad (1995) and Jorion (1991) who orthogonalised the exchange rate relative to the market. Usually in the literature the market effect is removed from the exchange rate, but since the purpose of the paper is to protect against a predicted exchange rate movement it was decided to rather remove the exchange rate effect from the market through (6.2). As shown on Giliberto (1985) the Top40 coefficient is equal in value to the orthogonalised Top40 coefficient. This allows the possibility of still examining the market risk of a portfolio, while obtaining independent explanatory variables.

The orthogonalised coefficients were estimated for each of the shares in the Top40 using this two-step approach. First the Top40 Index was orthogonalised relative to the exchange rate using equation (6.2) and then equation (6.3) was run, giving the required estimated coefficients. Once this had been completed, it was possible to investigate the two portfolio estimation techniques.
6.3.1 The Naïve method

The first technique was to estimate the exchange rate and orthogonalised Top40 coefficients using equation (6.4). Excel’s solver was then used to construct a portfolio from the available shares that maximised the portfolio’s exchange rate coefficient. To disallow portfolios that were overly weighted in one share or invested tiny amounts in shares a constraint was added that forced an investment in a share to either be 0 or constitute between 5 and 25 percent of the portfolio. The constraints allowed for only one portfolio to be optimal and it had to include at least 4 shares. This meant that the 4 shares with the highest R/S coefficient were selected. This method would correspond with an investor anticipating a R/$ depreciation, or trying to hedge against one, with the assumption that if a share had a relatively high R/$ coefficient over the estimation period then it would still have a positive R/$ coefficient over the test period. The portfolio’s Top40 regression coefficient was used to gauge the market risk of the portfolio.

6.3.2 The Efficient Frontier method

The concept behind the second method was to calculate an efficient frontier allowing for not only movements in the market but also the exchange rate. This is the reason behind the multi-index approach. Equation (6.6) reduces the problem of estimating the return for each portfolio to a matter of estimating expected returns for the orthogonalised Top40 Index and the exchange rate. The expected return on the Top40 Index was taken as the average annual return over the estimation period. Since the Top40 has performed remarkably well over the past few years the average is unlikely to be a good indicator for future performance. Following advice from Professor Brian Kantor an expected return of the R153, a fixed coupon South African government bond maturing in August 2010, plus 4% was examined as well. This only left an expected return for the exchange rate to be estimated. Since the purpose of this paper is to provide a method of hedging against a possible R/$ depreciation, various expected returns for the exchange rate were used. The expected
returns examined were a 5%, 10%, 15% and 20% depreciation in the R/S exchange rate. These expectations need not be accurate as effectively the investor is requiring a list of shares to invest in for a given anticipated depreciation. The effect of changing the expected return of the exchange rate is examined later. Once the expected return for the Top40 Index and the R/S exchange rate are fixed it is possible to calculate the expected return of the orthogonalised Top40 through (6.2).

The problem then becomes one of finding the minimum variance portfolio, assuming an average return in the market with an expected depreciation of the Rand relative to the Dollar for each possible return on a portfolio. Thus one is using an average to estimate the return on the market and examining how the efficient frontier changes for each estimated return on the exchange rate.

Graphically one is looking at the following picture:

![Efficient frontier for different expected depreciations](image)

*Figure 6.1: Efficient frontier for different expected depreciations*

Where

- $R_p$ is the return on a portfolio
- $\sigma_p$ is the standard deviation of a portfolio
- $E(R_p)$ is the expected change in the exchange rate
Chapter 6: Hedging against R/S depreciation

The shaded region is an efficient frontier for differing values of \( E(R_S) \). The idea is to see how the constituents of the portfolios on the efficient frontier change as the expected return on the R/S rate changes. In this case only positive values of \( E(R_S) \) are examined, these correspond to depreciations in the Rand relative to the dollar.

Instead of the usual efficient frontier, where one examines which portfolio of shares would have been optimal over the estimation period, this specification implies one is examining which portfolio of shares will be optimal if the market performed as it had and the exchange rate does something specified, such as depreciate by 5%. Though this may seem to be imposing a specific relationship between the Top40 and the exchange rate, this assumption can be dropped later. In order to examine the effects of differing expectations of the R/S on the efficient frontier 4 cross sections along the Rp axis in Figure 1 were examined, these were for 5%, 10%, 15% and 20% expected annual depreciations in the R/S exchange rate. This gave 4 efficient frontiers for each window period.

Once the efficient frontier was determined the portfolio that maximised the Sharpe ratio \(((E(R_S) - \text{risk-free rate}) / \text{portfolio standard deviation})\) was selected for testing. The average yield of the R153 was taken as the risk-free rate. Similarly to the previous method constraints were placed on the minimum and maximum possible allocations to each possible share with 5% being the minimum and 25% being the maximum. A constraint was added that ensured that the Top40 coefficient was within 0.15 of 1 to ensure that the portfolio was able to maintain exposure to the market while hedging against a depreciation. Only shares with consistently positive R/S coefficients were looked at, this gave 16 shares to pick from, namely Anglo American PLC (AGL), Anglo Platinum (AMS), Anglogold Ashanti Ltd (ANG), BHP Billiton PLC (BIL), Gold Fields Ltd (GFI), Harmony Gold Mining Ltd (HAR), Impala Platinum Holdings Ltd (IMP), Kumba Ltd (KMB), Liberty International PLC (LBT), Richemont Securities AG (RCH), Remgro Ltd (REM), SAB Miller PLC (SAB), Sappi Ltd (SAP), Steinhoff International Holdings Ltd (SHF) and
Chapter 6: Hedging against R/S depreciation

SASOL Ltd (SOL)

The performance of the selected portfolio was examined for the 12 months after the estimation period, with the assumption that the portfolio was rebalanced monthly to the allocation set out in the estimation period.

Both methods used 54 months of data to estimate their portfolios for the next 12 month period, at the end of 12 months the portfolios were re-estimated. This gave three portfolio test periods for each method, July 2003-June 2004, July 2004-June 2005 and July 2005-June 2006. These corresponded to the three estimation windows: January 1999-June 2003, January 2000-June 2004 and January 2001-June 2005.

6.4 Empirical Results

There were three test periods to evaluate for each of the methods. Each method was evaluated on two aspects, the orthogonalised R/S coefficient and the risk-adjusted return during the test period. Since the objective is to hedge against a R/S depreciation, the return during the months that the R/S depreciated is also looked at separately from the periods when the Rand appreciated against the dollar.

The method using the maximisation of the R/S coefficient produced the following portfolios during the three construction periods, only shares that were selected in a portfolio are displayed.
Chapter 6: Hedging against R/$ depreciation

<table>
<thead>
<tr>
<th>Portfolio allocations</th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMP</td>
<td>25%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>AMS</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>SOL</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>LBT</td>
<td>25%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>HAR</td>
<td>0%</td>
<td>0%</td>
<td>25%</td>
</tr>
<tr>
<td>AGL</td>
<td>0%</td>
<td>0%</td>
<td>25%</td>
</tr>
</tbody>
</table>

| R/$ coefficient       | 0.8625 | 0.7706 | 0.9208 |
| Top40 coefficient     | 1.1362 | 1.2221 | 1.1995 |
| Start                 | 1999/01/31 | 2000/01/31 | 2001/01/31 |
| End                   | 2003/06/30 | 2004/06/30 | 2005/06/30 |

Table 6.1: Portfolio allocations for maximising R/$ coefficient

Even though all of the Top40 shares were available to pick from only six were selected over the three periods, and thus the portfolios are similar. This shows the stability of the ranking of the R/$ coefficients, the four highest R/$ coefficients in the second period belong to the same set of shares with the four highest R/$ coefficients in the first period. Two of those four have are in the top four in the last period. This shows that by selecting the set of share with the highest R/$ coefficients allows for relatively consistent portfolios with respect to their constituents and thus rebalancing is less of a problem as it may be in other cases.

The following table represents the activity of the portfolios during the test period. N1, N2 and N3 represent the portfolio for the first, second and third test period respectively.

<table>
<thead>
<tr>
<th></th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
</tr>
</thead>
<tbody>
<tr>
<td>R/$ coefficient</td>
<td>0.4964</td>
<td>0.8346</td>
<td>1.3769</td>
</tr>
<tr>
<td>Top40 coefficient</td>
<td>1.0051</td>
<td>0.5523</td>
<td>1.9850</td>
</tr>
<tr>
<td>Start</td>
<td>2003/07/31</td>
<td>2004/07/31</td>
<td>2006/07/31</td>
</tr>
<tr>
<td>End</td>
<td>2004/06/30</td>
<td>2005/06/30</td>
<td>2006/06/30</td>
</tr>
</tbody>
</table>

Table 6.2: Orthogonalised coefficients of portfolios during test period.
Table 6.2 shows that while the R/S coefficient is not consistent with respect to the value during the portfolio construction period and the test period, at least the sign remains consistent. In addition to this table, it is important to see how the portfolios performed with respect to returns during periods when the R/S depreciated and when it appreciated. Ideally one would like the portfolio to perform better when the R/S depreciated. These values are displayed in the tables on the following page (Tables 6.3-6.5).
### Table 6.3: Performance of P1 from 2003/07/31 to 2004/06/30

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>R/$</th>
<th>Top40</th>
<th>Portfolio when R/$ Appreciated</th>
<th>Portfolio when R/$ depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average return</td>
<td>13.40%</td>
<td>-19.70%</td>
<td>21.20%</td>
<td>2.55%</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>19.76%</td>
<td>19.99%</td>
<td>15.45%</td>
<td>19.50%</td>
</tr>
<tr>
<td>Return/Std. Deviation</td>
<td>0.678</td>
<td>-0.986</td>
<td>1.372</td>
<td>0.131</td>
</tr>
<tr>
<td>count</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>9</td>
</tr>
</tbody>
</table>

### Table 6.4: Performance of P2 from 2004/07/31 to 2005/06/30

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>R/$</th>
<th>Top40</th>
<th>Portfolio when R/$ Appreciated</th>
<th>Portfolio when R/$ depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average return</td>
<td>39.52%</td>
<td>8.10%</td>
<td>36.04%</td>
<td>1.53%</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>21.16%</td>
<td>18.80%</td>
<td>16.28%</td>
<td>14.49%</td>
</tr>
<tr>
<td>Return/Std. Deviation</td>
<td>1.868</td>
<td>0.431</td>
<td>2.214</td>
<td>0.105</td>
</tr>
<tr>
<td>count</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

### Table 6.5: Performance of P3 from 2005/07/31 to 2006/06/30

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>R/$</th>
<th>Top40</th>
<th>Portfolio when R/$ Appreciated</th>
<th>Portfolio when R/$ depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average return</td>
<td>70.73%</td>
<td>6.21%</td>
<td>43.91%</td>
<td>76.87%</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>31.94%</td>
<td>16.37%</td>
<td>16.16%</td>
<td>17.00%</td>
</tr>
<tr>
<td>Return/Std. Deviation</td>
<td>2.214</td>
<td>0.380</td>
<td>2.718</td>
<td>4.521</td>
</tr>
<tr>
<td>count</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

Where “count” refers to the number of months in the test period that is applicable to the column label.
It is evident from the tables that over the periods of investigation R/$ depreciation has not been as pronounced as in previous years. This can be seen by looking at the values for the annual R/$ return and the fact that in each of the years examined there were more months where the Rand appreciated relative to the Dollar than there were where the Rand depreciated to the dollar. The important statistics in the tables are that of the performance of the portfolio when the R/$ depreciated and when it appreciated. As can be seen in the table for the first two periods the portfolio selection method was successful in that the portfolio performed better when the R/$ depreciated than it did when the R/$ appreciated and the difference is quite large. The last period is different in that the portfolio performed better when the R/$ appreciated than when it depreciated. This is examined later.

The second portfolio construction method produced more portfolios as for each construction period a portfolio was constructed for a 5%, 10%, 15% and 20% expected annual depreciation in the R/$ rate.

The following table shows the allocations for each estimated depreciation in the exchange rate for the each of the first estimation period. Only shares that were selected in at least one portfolio are shown.

<table>
<thead>
<tr>
<th>Expected depreciation of Rand relative to Dollar</th>
<th>5.00%</th>
<th>10.00%</th>
<th>15.00%</th>
<th>20.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMP</td>
<td>0.2500</td>
<td>0.2500</td>
<td>0.2500</td>
<td>0.2406</td>
</tr>
<tr>
<td>SOL</td>
<td>0.1655</td>
<td>0.1729</td>
<td>0.2445</td>
<td>0.2129</td>
</tr>
<tr>
<td>LBT</td>
<td>0.0845</td>
<td>0.1865</td>
<td>0.2438</td>
<td>0.2500</td>
</tr>
<tr>
<td>BIL</td>
<td>0.2500</td>
<td>0.1658</td>
<td>0.0797</td>
<td>0.1109</td>
</tr>
<tr>
<td>GFI</td>
<td>0.2500</td>
<td>0.2248</td>
<td>0.1826</td>
<td>0.1856</td>
</tr>
</tbody>
</table>

Table 6.6: Portfolio allocations for the first period for each expected depreciation in the exchange rate.

The portfolios are remarkably similar, both in terms of constituents and in terms of allocations. This shows that the level of expected depreciation is not as important as expecting a depreciation of any value. This is an important result which suggests
that there is a “best” set of shares to invest in irrespective of the level of expected depreciation as long as a depreciation is anticipated or needed to be hedged against.

Given the similarity between the portfolios, only the results corresponding to the portfolios formed with a 20% expected depreciation in the R/$ exchange rate are displayed. This makes the portfolio selection method comparable to the first method where the R/$ coefficient was maximised and would benefit most from a large depreciation in the R/$ exchange rate. The next table displays the portfolio allocations for the multi index efficient frontier method for each estimation window. Portfolios are labelled M1, M2 and M3 corresponding to the first, second and third test periods respectively.

<table>
<thead>
<tr>
<th>Portfolio allocations</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMP</td>
<td>0.2406</td>
<td>0.0915</td>
<td>0.0000</td>
</tr>
<tr>
<td>SOL</td>
<td>0.2129</td>
<td>0.2227</td>
<td>0.2500</td>
</tr>
<tr>
<td>LBT</td>
<td>0.2500</td>
<td>0.2500</td>
<td>0.1786</td>
</tr>
<tr>
<td>BIL</td>
<td>0.1109</td>
<td>0.0500</td>
<td>0.2500</td>
</tr>
<tr>
<td>KMB</td>
<td>0.0000</td>
<td>0.1446</td>
<td>0.1422</td>
</tr>
<tr>
<td>GFI</td>
<td>0.1856</td>
<td>0.0000</td>
<td>0.1791</td>
</tr>
<tr>
<td>REM</td>
<td>0.0000</td>
<td>0.241</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

R/$ coefficient: 0.7367, 0.6087, 0.7581
Top40 coefficient: 0.9885, 0.8500, 0.8500

<table>
<thead>
<tr>
<th>Start</th>
<th>1999/01/31</th>
<th>2000/01/31</th>
<th>2001/01/31</th>
</tr>
</thead>
<tbody>
<tr>
<td>End</td>
<td>2003/06/30</td>
<td>2004/06/30</td>
<td>2005/06/30</td>
</tr>
</tbody>
</table>

Table 6.7: Portfolio allocations for Multi index optimisation

Whereas the method that maximised the R/$ coefficient used four shares at a time, this method never uses less than five, with seven shares used over the entire test period. The portfolios are relatively consistent with regard to their constituents, with each portfolio sharing 4 shares with the next period’s optimal portfolio. LBT, SOL and BIL appear in each of the portfolios, with SOL and LBT consistently receiving high allocations. This shows that resource stocks are not necessarily the best hedges, but rather dual listed shares and SASOL.
The tables on the following page (tables 6.8-6.10) show the performance of the portfolio using the same measures as before.

Even though this method differs from the previous method the results are similar in that the constructed portfolio performs better when the R/S depreciates for the first two periods but this is not so for the last period.

The explanation for the lower performance in the third period is not necessarily obvious. This is a strange result as it shows that two different sets of traditional Rand Hedges performed better when the Rand appreciated than when the Rand depreciated. A possible explanation is that this was due to shares rising due to positive sentiment that happened to occur while the Rand appreciated in value and this is plausible since the test period was a period of rapid share price growth that was not associated with higher R/S volatility.
Chapter 6: Hedging against R/$ depreciation

### Table 6.8: Performance of M1 from 2003/07/31 to 2004/06/30

<table>
<thead>
<tr>
<th></th>
<th>Portfolio</th>
<th>R/$</th>
<th>Top40</th>
<th>Portfolio when R/$ Appreciated</th>
<th>Portfolio when R/$ depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average return</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>10.12%</td>
<td>-19.70%</td>
<td>21.20%</td>
<td>2.60%</td>
<td>32.67%</td>
</tr>
<tr>
<td><strong>Std. Deviation</strong></td>
<td>18.65%</td>
<td>19.99%</td>
<td>15.45%</td>
<td>18.34%</td>
<td>21.97%</td>
</tr>
<tr>
<td><strong>Return/Std. Deviation</strong></td>
<td>0.54</td>
<td>-0.99</td>
<td>1.37</td>
<td>0.14</td>
<td>1.49</td>
</tr>
<tr>
<td><strong>count</strong></td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 6.9: Performance of M2 from 2004/07/31 to 2005/06/30

<table>
<thead>
<tr>
<th></th>
<th>Portfolio</th>
<th>R/$</th>
<th>Top40</th>
<th>Portfolio when R/$ Appreciated</th>
<th>Portfolio when R/$ depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average return</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2</td>
<td>47.30%</td>
<td>8.10%</td>
<td>36.04%</td>
<td>22.61%</td>
<td>81.86%</td>
</tr>
<tr>
<td><strong>Std. Deviation</strong></td>
<td>14.94%</td>
<td>18.80%</td>
<td>16.28%</td>
<td>12.64%</td>
<td>12.67%</td>
</tr>
<tr>
<td><strong>Return/Std. Deviation</strong></td>
<td>3.17</td>
<td>0.43</td>
<td>2.21</td>
<td>1.79</td>
<td>6.46</td>
</tr>
<tr>
<td><strong>count</strong></td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

### Table 6.10: Performance of M3 from 2005/07/31 to 2006/06/30

<table>
<thead>
<tr>
<th></th>
<th>Portfolio</th>
<th>R/$</th>
<th>Top40</th>
<th>Portfolio when R/$ Appreciated</th>
<th>Portfolio when R/$ depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average return</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M3</td>
<td>54.72%</td>
<td>6.21%</td>
<td>43.91%</td>
<td>77.24%</td>
<td>23.19%</td>
</tr>
<tr>
<td><strong>Std. Deviation</strong></td>
<td>22.34%</td>
<td>16.37%</td>
<td>16.16%</td>
<td>10.76%</td>
<td>31.96%</td>
</tr>
<tr>
<td><strong>Return/Std. Deviation</strong></td>
<td>2.45</td>
<td>0.38</td>
<td>2.72</td>
<td>7.18</td>
<td>0.73</td>
</tr>
<tr>
<td><strong>count</strong></td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

Where “count” refers to the number of months in the test period that is applicable to the column label.
Chapter 6: Hedging against R/$ depreciation

The last investment option examined was the ITRIX Exchange traded Fund. Since this is based on the FTSE 100 it should give a natural hedge to the R/$ exchange rate as the correlation between the British Pound and the American Dollar is traditionally very high.

The following table gives the coefficient values of the ITRIX fund for the three test periods:

<table>
<thead>
<tr>
<th></th>
<th>R/$ Beta</th>
<th>Top40 coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITRIX fund</td>
<td>0.960</td>
<td>0.425</td>
</tr>
<tr>
<td>ITRIX fund</td>
<td>0.614</td>
<td>0.317</td>
</tr>
<tr>
<td>ITRIX fund</td>
<td>0.537</td>
<td>0.133</td>
</tr>
</tbody>
</table>

| Start      | 2003/07/31 | 2004/07/31 | 2005/07/31 |
| End        | 2004/06/30 | 2005/06/30 | 2006/06/30 |

Table 6.11: ITRIX's orthogonalised coefficients during test periods.

The positive values for the R/$ coefficient confirm the belief that the ITRIX should act as a natural hedge against Rand depreciation while the relatively low Top40 coefficient confirms the ITRIX’s weak relationship with the performance in the South African market.

The returns for the simulated ITRIX fund are displayed in the tables on the following page (tables 6.12-6.14). As can be seen the ITRIX fund always performs better when the R/$ depreciates than it does when the R/$ appreciates. This comes at the expense of a lower return for the fund, this is due to the fact that as the shares are based in England they would not have been able to participate in the recent rapid growth seen on the JSE.
### Chapter 6: Hedging against R/$ depreciation

#### Table 6.12: Performance of II from 2003/07/31 to 2004/06/30

<table>
<thead>
<tr>
<th></th>
<th>Portfolio</th>
<th>R/$</th>
<th>Top40</th>
<th>Portfolio when R/$ Appreciated</th>
<th>Portfolio when R/$ depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average return</td>
<td>6.32%</td>
<td>-19.70%</td>
<td>21.20%</td>
<td>-27.35%</td>
<td>107.34%</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>21.63%</td>
<td>19.99%</td>
<td>15.45%</td>
<td>13.84%</td>
<td>10.28%</td>
</tr>
<tr>
<td>Return/std deviation</td>
<td>0.292</td>
<td>-0.986</td>
<td>1.372</td>
<td>-1.977</td>
<td>10.442</td>
</tr>
<tr>
<td>count</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Table 6.13: Performance of I2 from 2004/07/31 to 2005/06/30

<table>
<thead>
<tr>
<th></th>
<th>Portfolio</th>
<th>R/$</th>
<th>Top40</th>
<th>Portfolio when R/$ Appreciated</th>
<th>Portfolio when R/$ depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average return</td>
<td>25.01%</td>
<td>8.10%</td>
<td>36.04%</td>
<td>-0.97%</td>
<td>61.37%</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>12.33%</td>
<td>18.80%</td>
<td>16.28%</td>
<td>5.91%</td>
<td>11.38%</td>
</tr>
<tr>
<td>Return/std deviation</td>
<td>2.028</td>
<td>0.431</td>
<td>2.214</td>
<td>-0.164</td>
<td>5.395</td>
</tr>
<tr>
<td>count</td>
<td>12</td>
<td>12</td>
<td>7</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

#### Table 6.14: Performance of I3 from 2005/07/31 to 2006/06/30

<table>
<thead>
<tr>
<th></th>
<th>Portfolio</th>
<th>R/$</th>
<th>Top40</th>
<th>Portfolio when R/$ Appreciated</th>
<th>Portfolio when R/$ depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average return</td>
<td>26.02%</td>
<td>6.21%</td>
<td>43.91%</td>
<td>13.23%</td>
<td>43.94%</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>9.11%</td>
<td>16.37%</td>
<td>16.16%</td>
<td>7.99%</td>
<td>8.67%</td>
</tr>
<tr>
<td>Return/std deviation</td>
<td>2.856</td>
<td>0.380</td>
<td>2.718</td>
<td>1.655</td>
<td>5.071</td>
</tr>
<tr>
<td>count</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

Where “count” refers to the number of months in the test period that is applicable to the column label.
Chapter 6: Hedging against R/S depreciation

The following tables provide a comparison of the three possible methods of R/S hedging using portfolio allocation. Each method is compared on its return and average regression coefficients over the three estimation periods. N represents the portfolio that maximised the R/S coefficient. M refers to the portfolio derived from the multi index efficient frontier approach and I refers to the ITRIX 100.

<table>
<thead>
<tr>
<th></th>
<th>Average return</th>
<th>Average return when R/S Appreciated</th>
<th>Average return when R/S depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>41.22%</td>
<td>26.98%</td>
<td>66.94%</td>
</tr>
<tr>
<td>M</td>
<td>37.38%</td>
<td>34.15%</td>
<td>45.90%</td>
</tr>
<tr>
<td>I</td>
<td>19.12%</td>
<td>-5.03%</td>
<td>70.89%</td>
</tr>
</tbody>
</table>

Table 6.15: Performance of the three Rand Hedge methods

<table>
<thead>
<tr>
<th></th>
<th>Average R/S coefficient</th>
<th>Average Top40 coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>0.9026</td>
<td>1.1808</td>
</tr>
<tr>
<td>M</td>
<td>0.4790</td>
<td>0.9716</td>
</tr>
<tr>
<td>I</td>
<td>0.7040</td>
<td>0.2919</td>
</tr>
</tbody>
</table>

Table 6.16: Regression coefficients of the three Rand Hedge methods

If the R153 plus 4% is used to estimate the return on the Top40 instead of the average return over the estimation period, as suggested by Professor Kantor then the following results are obtained for the efficient frontier model.

<table>
<thead>
<tr>
<th></th>
<th>Average return</th>
<th>Average return when R/S Appreciated</th>
<th>Average return when R/S depreciated</th>
</tr>
</thead>
<tbody>
<tr>
<td>M’</td>
<td>39.69%</td>
<td>35.44%</td>
<td>52.44%</td>
</tr>
</tbody>
</table>

Table 6.16: Performance of efficient frontier method with R153 +4% as expected Top40 return

<table>
<thead>
<tr>
<th></th>
<th>Average R/S coefficient</th>
<th>Average Top40 coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>M’</td>
<td>0.5870</td>
<td>0.9743</td>
</tr>
</tbody>
</table>

Table 6.17: Regression coefficients of the efficient frontier method with R153 +4% as expected Top40 return

These results are very similar to the results obtained for the efficient frontier method when the past performance of the Top40 Index was used to predict the future performance. Since the expected returns are similar this suggests that the results of
the efficient frontier method are not greatly affected by the expectation placed on the Top40 Index.

The ITRIX provides the highest average return when the Rand depreciates against the Dollar, and the lowest of the average returns when the Rand appreciates. This suggests that the ITRIX is the most effective Rand Hedge of the methods surveyed. The regression coefficients tell a different story. The R/$ coefficient maximisation method comes out with both the highest average R/$ Beta and the highest average Top40 Beta, reflecting the higher risk inherent in this method. The efficient frontier approach has a lower R/$ coefficient than the ITRIX but an average Top40 coefficient that is closer to 1 and higher than the ITRIX’s Top40 coefficient. These statistics reveal the problem associated with simply investing in the ITRIX, that of lower exposure to the South African market. Recently this would have led to lower returns as the Top40 has done extremely well recently. This is reflected by the fact that the ITRIX had the lowest average return of the three methods investigated.

6.3 Conclusions

The results show that it is possible, in general, to hedge against a R/$ depreciation by investing locally and that even a simple portfolio construction technique that does not pay attention to risk of the portfolio is able to perform better when the R/$ depreciates than when it appreciates. In terms of hedging against a R/$ depreciation the results show that while the ITRIX fund provides more consistent hedging this comes at the expense of a weak relationship with the Top40. Thus it would seem that the Multi-index efficient frontier approach is the best as it allows for higher risk-adjusted returns than the beta maximising approach, while allowing for more correlation with the market than the ITRIX approach. The constituents of the multi-index optimisation method show that resource stocks are not necessarily the default Rand Hedges, in some cases dual listed shares perform better.
Chapter 7: Pricing of exchange rate exposure

The previous chapters have shown that cross sectional differences in exposure to the exchange rate exist. Many shares have significant exposure, some negative and some positive. Given that the exchange rate is significant in explaining some of the movement in particular shares, it is important to determine if the exchange rate is priced. The objective of this chapter is to determine whether there is a risk premium attached to foreign exchange exposure, and whether this pricing is stable.

In South Africa, as shown in the informal literature review, the Rand receives substantial attention in the domestic press as a determinant of market movements and in addition is often associated with market sentiment. From 1996 to 2001, the Rand consistently reached new levels of weakness and since then the Rand has stabilised, and is not viewed as negatively. These facts lead to the following questions:

1) Is R/$ exposure priced? i.e. is exchange rate exposure rewarded, penalised or ignored by the market?

2) Has the pricing of this risk changed with the difference in the performance of the Rand?

The Arbitrage Pricing Theory was devised by Ross (1976) as an alternative to the Capital Asset Pricing Model (CAPM). Using APT it is possible to price factors other than the market and in this case the focus will be on the R/$ exchange rate. APT
literature is broadly divided into two branches, one where Factor Analysis is used to
determine the factors and the other where a prespecified set of factors, generally
macroeconomic in nature, is selected. Both methods have advantages, Burmeister
and McElroy (1988) pointed out the main advantages of the prespecified approach;
one can attach economic interpretations to the significant, prespecified factors and
using macroeconomic variables is useful in that asset price behaviour can be linked
to changes in macroeconomic variables instead of other asset prices.

The use of a prespecified two-index model in the previous chapters links with the
prespecified APT. In this case, the factors are the exchange rate and the Top40
Index. Chen, Roll and Ross (1986) examined the pricing of prespecified economic
factors and found industrial production, the term structure of interest rates and the
difference in return between the return for AAA bonds and BAA bonds to be priced.
Van Rensburg (2002) used principal component analysis and found that the
Financial and Industrial Index and the Resources index should be used in a two­
factor APT model to explain returns on the J.S.E. This is applicable as one of the
main differences between the Financial and Industrial Index and the Resources
Index is their classification vis-à-vis Rand Play, Rand Hedge and Rand leverage.
This implies that if a prespecified multifactor approach were to be taken when
modelling returns on the J.S.E., the R/S exchange rate should be one of those
factors.

In this case, the primary objective is to determine the pricing of exchange rate
exposure in the South African context. Using the two index model of the previous
chapter, where each share’s return is expressed as a linear function of the return in
the Top40 and the change in the R/$ rate \((7.1)\), it is possible to determine the pricing
of the exchange rate.

\[
r_s = a + b_1 I_{t_1} + b_2 I_{t_2}, \tag{7.1}
\]
Chapter 7: Pricing of exchange rate exposure

Where

$I_{1t}$ is the return on the R/$ exchange rate at time $t$

$I_{2t}$ is the return on the Top40 Index at time $t$

In order to aid calculations further on the indices are made to have a mean of zero through (7.2)

$$I_{nt}^* = I_{nt} - \bar{I}_n$$  for $n=1,2$ (7.2)

Where $\bar{I}_n$ is the average return of $I_n$

This gives equation (7.3) as the new multi-index model.

$$r_i = a_i + b_{1i}I_{1t}^* + b_{2i}I_{2t}^*$$ (7.3)

If necessary, these indices can be orthogonalised to remove any correlation.

Using the notation in Elton et al.’s (2000) book, the expected return on a security $i$ can be expressed as equation (7.4)

$$E(r_i) = \lambda_0 + \lambda_1 b_{1i} + \lambda_2 b_{2i}$$ (7.4)

By constructing specific portfolios, it is possible to interpret the lambda values. The following three portfolios allow for this interpretation.
Chapter 7: Pricing of exchange rate exposure

1) A portfolio with all of the b values equal to zero

i.e. \( b_{11} \) and \( b_{12} = 0 \)

In this case \( E(r) = \lambda_0 \). This is a zero-beta portfolio and the expected return is taken as the risk-free rate \( (r_f) \)

Substituting \( r_f \) for \( \lambda_0 \) gives:

\[
\lambda_1 = r_f + \lambda_1
\]

\[
\therefore \lambda_1 = \bar{r}_1 - r_f
\]

This implies that \( \lambda_1 \) is the extra return above the risk-free rate that a portfolio constructed to have \( b_{12} = 0 \) and \( b_{11} = 1 \) would be expected to have. This is the extra return, above the risk free rate, that one would expect to receive for increasing exposure to the exchange rate, measured by \( b_{11} \), by one unit.

2) \( b_{12} = 1 \) and \( b_{11} = 0 \)

Substituting \( r_f \) for \( \lambda_0 \) gives:

\[
r_{12} = r_f + \lambda_2
\]

\[
\therefore \lambda_2 = \bar{r}_{12} - r_f
\]

This implies that \( \lambda_2 \) is the extra return above the risk-free rate that a security gains by a one unit increase in its exposure to the Top40, measured by \( b_{12} \).

3) \( b_{11} = 0 \) and \( b_{12} = 1 \)

Substituting \( r_f \) for \( \lambda_0 \) gives:

\[
r_{21} = r_f + \lambda_3
\]

\[
\therefore \lambda_3 = \bar{r}_{21} - r_f
\]

This implies that \( \lambda_3 \) is the extra return above the risk-free rate that a security gains by a one unit increase in its exposure to the Top40, measured by \( b_{12} \).

This allows for interpretation of the \( \lambda \) values. \( \lambda_0 \) is the risk-free rate and is estimated by the 3-month treasury bill (T-bill) rate. This follows from Firer (1993) who, in a review of papers that used an estimate for the risk free rate in South Africa, showed that t-bills are the most widely used. In his paper he mentions that Affleck Graves, Burt & Cleasby (1988) and Page and Palmer (1991) used the 90 day t-bill rate as an
estimate for the risk-free rate. The remaining $\lambda$ values correspond to the increase in returns above the risk-free rate for an increase in one of the respective $b$ values.

Taking expected values on (7.3) gives the following equation.

$$E(r_i) = a_i + b_{11}E(I'_{1u}) + b_{12}E(I'_{2u})$$

but following on from (7.2)

$$E(I'_{nt}) = 0 \text{ for } n=1,2$$

$$\therefore E(r_i) = a_i \quad (7.5)$$

As can be seen by equation (7.5), $a_i$ can be expressed as the average return on security $i$. The average return on security $i$ already has an equation, equation (7.4). Substituting (7.4)'s equation for the average return on security $i$ into (7.3), replacing $a_i$, gives (7.7).

$$r_i = \lambda_0 + \lambda_1b_{11} + \lambda_2b_{12} + b_{11}I'_{1u} + b_{12}I'_{2u} \quad (7.7)$$

This model is similar to the one tested by Jorion in 1991. Jorion (1991) orthogonalised the exchange rate relative to the market and was thus measuring the pricing of what Liang and Mougoue (1994) termed incremental exposure. Jorion (1991) pointed out that the exchange rate term was appropriate if changes in the exchange rate were unanticipated, which he showed they were. Jorion tested industry portfolios and found that exchange rate risk was not priced in the U.S.A. Liang and Mougoue found that American Depository Receipts (ADRs) incremental
exposure to foreign exchange risk is not priced.

These results do not necessarily apply to the South African context for a few reasons. Firstly, Jorion (1991) used a trade-weighted exchange rate. As discussed earlier this could bias downwards any reported exposure as it may include currencies that are exposed to in different directions. Secondly, oil and most resources are priced in Dollars so one would expect there to be a lowered relationship between returns and any exchange rate fluctuation for U.S. companies. One would expect exchange rate exposure in a country like South Africa to be higher than that in the U.S. The following two sections address the pricing and stability of the pricing of exchange rate exposure for South African shares.

### 7.1 Is R/$ exposure priced?

Multi-index models require the indices in the model to be independent. Given the correlation between the exchange rate and the Top40 over certain periods, it is necessary to orthogonalise the variables with respect to each other. This raises the question of which explanatory variable to orthogonalise. Conventionally the exchange rate will be regressed against the Top40 and the residuals of this regression will become the new exchange rate term. This is the approach taken by Jorion (1991), Choi and Prasad (1995) and others. This has the effect of removing the market effect from the exchange rate and by testing the pricing of the exchange rate one is actually testing the pricing of exposure that is different from the exposure of the Top40. Liang and Mougoue (1994) paper termed this excess exposure “incremental exposure”, and for clarity, that term will be used here as well.

In this chapter, as in the earlier chapters, the factors are assumed a priori and then tested afterwards. This is similar to the approach taken by Chen, Roll and Ross
Chapter 7: Pricing of exchange rate exposure

(1986). In the case of this chapter, the factors are determined simultaneously and thus there is scope for orthogonalising the Top40 relative to the exchange rate. This would have the effect of removing the exchange rate effect from the Top40 and by examining the pricing of exchange rate risk one would now be examining the pricing of exchange rate exposure in its entirety.

Theoretically, if one concurs with the belief that market risk is priced then the pricing of exchange rate exposure in its entirety should be more significant than incremental exposure as it will contain exposure that has already been priced (the market’s exposure to the exchange rate). The problem with this is that incremental exposure may be priced in the opposite direction to the exposure of the market to the exchange rate.

This implies that it is necessary to not only examine the pricing of incremental exchange rate exposure, but also the pricing of exposure to the entire movement in the exchange rate. Both methods of orthogonalisation are examined here. In addition, the situation where the return on the Top40 Index is not taken as a factor but rather as a set of returns that can be used to explain the movement of an unobserved unspecified factor is examined.

Since a system of equations is used, there is also a question as to which estimation method to use. Burmeister and McElroy (1988) provided a comparison of three system regression techniques with respect to their application to testing the pricing of factors. They compared iterated non-linear weighted least squares regression, iterated non-linear seemingly unrelated regression and iterated non-linear three stage least squares regression. Each of these is applicable to a different set of assumptions relating to the error terms and will be examined here.

As with the previous chapters, the universe of shares is restricted to constituents of
the Top 40 to avoid problems associated with thin trading and to make the study applicable to investors. The following shares are used for the whole period: AGL, AMS, ANG, ASA, BAW, BIL, BVT, ECO, FSR, GFI, HAR, MLA, IMP, INL, INP, IPL, KMB, LBT, LGL, MTN, NED, NPK, NPN, NTC, OML, PIK, PPC, RCH, REM, RMH, SAB, SAP, SBK, SHF, SLM, SOL, TBS, TKG, VNF and WHL.

7.1.1 R/$ and an unobserved factor

This section addresses (7.7) when the indices are not orthogonalised relative to each other. Burmeister and McElroy (1988) were able to account for the effect of both observed and unobserved factors. They assumed that returns were generated by the following Linear Factor Model (LFM)

\[ r_t = b_0 + \sum_{j=1}^{J} b_j F_{j,t} + \epsilon_t \]  

(7.8)

Where

\[ E(F_{j,t}) = 0 \quad \forall j \]  

(7.8.1)

\[ E(\epsilon_t \epsilon_i) = \begin{cases} \sigma_{ij} & \text{for } i = j, \ t = s \\ 0 & \text{otherwise} \end{cases} \]  

(7.8.2)

\[ E(\epsilon_t | F_{.t}) = E(\epsilon_t) = 0 \]  

(7.8.3)

(7.8.1) implies that the expected value of each of the factors is 0. This is possible as each factor can be transformed to have a mean of zero through

\[ F_{j,t} = F_{j,t}^* - \bar{F}_j \]  

(Which is equivalent to equation (7.2))

Where
Chapter 7: Pricing of exchange rate exposure

\( F^\mu_j \) is the original, untransformed series of values for Factor \( j \)

\( \bar{F}^\mu_j \) is the arithmetic mean of Factor \( j \)

(7.8.2) implies that there is no cross-correlation between the errors at any lag (which will be relaxed later) and that there is no autocorrelation in the errors for any of the \( i \) returns. Cross-correlation in the errors would imply that a factor has been left out and the factor sensitivities (\( b_s \)) that are being measured could be prone to missing variable bias.

(7.8.3) implies that none of the factors convey information about the expected value of the errors.

(7.8) is a very general model and the CAPM and APT specifications are both special cases of this model. Burmeister and McElroy than split the factors into \( J \) unobserved factors and \( K-J \) observed factors, giving

\[
\sum_{j=1}^{J} b_j F^\mu_j = \sum_{j=1}^{J} b_j F^\mu_j + \sum_{j=J+1}^{K} c_g g^\mu_j
\]  

(7.9)

Where

\( f^\mu_j \) represents the value of unobserved factor \( f_j \) at time \( t \)

\( g^\mu_j \) represents the value of observed factor \( g_j \) at time \( t \)

Using Burmeister and McElroy’s notation one can then split \( N + J \) assets that (7.8) holds for into two groups, one with \( N \) assets and the other with \( J \).
Chapter 7: Pricing of exchange rate exposure

\[ r_t = b_0 + B f_t + C g_t + \varepsilon_t \]  \hspace{1cm} (7.10)

\[ R_t = b_{0J} + B_J f_t + C_J g_t + \varepsilon_J \]  \hspace{1cm} (7.11)

Where

\( r_t = (r_1, \ldots, r_N)' \) is the vector of returns for the first \( N \) assets

\( R_t = (r_{N+1}, \ldots, r_{N+J})' \) is the vector of the last \( J \) assets

The previous assumptions about the error term are carried through i.e.

\[ E(\varepsilon_t) = 0 \]  \hspace{1cm} (\( 0 \) is a \( N \times 1 \) vector)

\[ E(\varepsilon_J) = 0 \]  \hspace{1cm} (\( 0 \) is a \( J \times 1 \) vector)

\[ E((\varepsilon_t)(\varepsilon_J)') = 0 \]  \hspace{1cm} (\( 0 \) is a \( N \times J \) matrix)

\[ E((\varepsilon_J)(\varepsilon_J)') = D_r \]  \hspace{1cm} (\( 0 \) is a \( N \times N \) matrix)

\[ E((\varepsilon_t)(\varepsilon_J)') = D_R \]  \hspace{1cm} (\( 0 \) is a \( J \times 1 \) matrix)

Where

\( D_r \) and \( D_R \) are diagonal matrices.

Solving (7.11) for the unobserved factors yields

\[ f_t = B_J^{-1} (R_t - b_{0J} - C_J g_t - \varepsilon_J) \]  \hspace{1cm} (7.12)

The inverse of \( B_J \) exists as \( B_J \) is \( J \times J \) (\( J \) observations with \( J \) factors) and is nonsingular (assuming no multicollinearity).
Substituting (7.12) into (7.10) gives

\[ r_t = b_0 + B(B_j^{-1}(R_t - b_{0j} - C_jg_t - \epsilon_j)) + Cg_t + \epsilon_t \]

\[ \therefore r_t = (b_0 - BB_j^{-1}b_{0j}) + (BB_j^{-1})R_t + (C - BB_j^{-1}C_j)g_t + (\epsilon_t - BB_j^{-1}\epsilon_j) \]

Re-labelling the terms in brackets gives

\[ r_t = \beta_0 + \beta R_t + \gamma g_t + \eta_t \]  

(7.13)

This result from Burmeister and McElroy is critical to this section. Burmeister and McElroy used three different return series to constitute \( R_t \). These act as surrogates for the unmeasured factors. In the specification in this thesis \( g_t \) is the return on the exchange rate and \( R_t \) is the return on the Top40 Index. This specification would imply that shares are determined by two factors, one is the exchange rate and the other is something else that is captured by the Top40 Index.

Burmeister and McElroy showed that it was possible to let \( B_j = I \), the Identity matrix. This makes intuitive sense, as \( B_j \) is the set of coefficients on the unobserved factors and letting \( B_j = I \) is equivalent to performing a transformation on the unobserved factors before regressing on them. This is acceptable as they are unobserved; the problem with this is that one loses the ability to interpret the pricing of the unobserved factors. In the specification using the \( RS \) exchange rate and the Top40 this has the implication of being able to interpret the pricing of the exchange rate, but the pricing of the other term is the pricing of a transformed unmeasured factor instead of the pricing of an unmeasured factor. One cannot determine the transformation without finding and measuring the unmeasured factor, which is clearly not possible as it is possibly a combination of other factors. Since the factors are unobserved it is also possible, without loss of generality, to assume that they are orthogonal to the observed factors, since this also only requires a transformation of
the unobserved factors.

The APT model is a special case of the Linear Factor Model with

\[ E(r_i) = \lambda_0 + \sum_{j=1}^{K} b_j \hat{\lambda}_j \quad (7.14) \]

(Which is equivalent to (7.4) for this chapter)

Following the same idea above, that of splitting the factors into observed and unobserved factors, it is possible to rewrite (7.14) as

\[ E(r_i) = \hat{\lambda}_0[n] + B \hat{\lambda}_j + C \hat{\lambda}_K \quad (7.15) \]

Where

- \( n \) is a 1 x N vector filled with 1s
- \( \hat{\lambda}_j = (\hat{\lambda}_1, \ldots, \hat{\lambda}_j)' \)
- \( \hat{\lambda}_K = (\hat{\lambda}_{j+1}, \ldots, \hat{\lambda}_K)' \)

Applying the APT cross-equation restrictions to (7.11) yields

\[ E(R_i) = \hat{\lambda}_0[n] + B_j \hat{\lambda}_j + C_j \hat{\lambda}_K \quad (7.16) \]

Taking expectations on (7.13) yields

\[ E(r_i) = \beta_0 + \beta E(R_i) \quad (7.17) \]

Substituting (7.16) into (7.17) gives
\[ E(r_t) = \beta_0 + \beta(\lambda_{0(I)} + B_J \tilde{\lambda}_J + C_J \tilde{\lambda}_K) \]  \hspace{1cm} (7.18)

(7.18) and (7.15) both give expressions for \( E(r_t) \), equating them and making \( \beta_0 \) the subject of the equation gives

\[ \beta_0 = \lambda_{0(I)} + B_J \tilde{\lambda}_J + C_J \tilde{\lambda}_K - \beta(\lambda_{0(I)} + B_J \tilde{\lambda}_J + C_J \tilde{\lambda}_K) \]

\[ \therefore \beta_0 = (\lambda_{0(I)} - \beta(\tilde{\lambda}_J + (B - \beta B_J) \tilde{\lambda}_J + (C - \beta C_J) \tilde{\lambda}_K) \]

\[ \therefore \beta_0 = (\lambda_{0(I)} - \beta_{0(I)}) \tilde{\lambda}_J + \gamma \tilde{\lambda}_K \]  \hspace{1cm} (7.19)

As

\[ \beta = BB_J^{-1} \]

\[ \gamma = C - \beta C_J \]

Burmeister and McElroy then substituted (7.19) into (7.13) giving

\[ r_t - \lambda_{0(I)} = \beta(R_t - \lambda_{0(I)}) + \gamma(\lambda_k + \gamma r_t + \eta_t) \]

Which gives

\[ r_t - \lambda_{0(I)} = \gamma \tilde{\lambda}_K + \beta(R_t - \lambda_{0(I)} + \gamma r_t + \eta_t) \]  \hspace{1cm} (7.20)

This was one of the models that Burmeister and McElroy tested. For the purposes of this chapter \( g_t \), the observed factor, is the R/S exchange rate. \( R_t \), which captures the unobserved factor, is the return on the Top40 Index. \( \lambda_0 \) is taken as the 3 month t-bill rate. Following Burmeister and McElroy the results for iterated non-linear two stage
weighted least squares regression, iterated non-linear seemingly unrelated regression and iterated non-linear three stage least squares regression were compared. The results for two stage non-linear regression were also examined. Each one of these regressions is associated with a specific set of error assumptions.

Seemingly unrelated regression (SUR) is used when error terms are correlated between equations. This correlation implies that there is at least one factor that has been omitted from the regression. Non-linear seemingly unrelated regression provides consistent and asymptotically normal estimates and if the errors are joint normal then the estimates are maximum likelihood estimates.

If the factors are correlated with the error terms, then instrumental variables are required. Burmeister and McElroy (1988) used the exogenous variables and twenty randomly selected shares that were not in their sample or in the S&P 500. Following this approach, the exogenous variables, i.e. the log returns of the R/$ exchange rate and the Top40 Index, were used in addition to the six largest shares outside of the Top40 that had data from June 1996 to June 2006. These shares were Aspen Pharmaceuticals (APN), African Rainbow Minerals (ARM), Foschini (FOS), J.D. Group (JDG), Reunert (RLO) and Shoprite (SHP)

Two Stage Least Squares (TSLS) is used when there is correlation between the exogenous variables and the error terms. First the endogenous and exogenous variables are regressed on instruments and then the estimated endogenous variables are regressed on the estimated exogenous variables. Weighted Two Stage Least Squares (WTSLS) accounts for heteroskedasticity in the residuals. Greene (2003) pointed out that WTSLS is more efficient than TSLS in the presence of heteroskedasticity and is equivalent to TSLS when heteroskedasticity is absent. Three Stage Least Squares (3SLS) is used when there is contemporaneous correlation in the residuals and the exogenous variables are correlated to the error.
terms. Each of the methods applies to a different set of error assumptions and it is thus interesting to examine the difference in estimated values.

The following table shows the results of running (7.20) for each of the system estimation techniques from June 1996 to June 2006.

<table>
<thead>
<tr>
<th></th>
<th>( \lambda )</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUR</td>
<td>7.7632</td>
<td>1.9522</td>
<td>0.0510</td>
</tr>
<tr>
<td>2SLS</td>
<td>0.4996</td>
<td>0.1385</td>
<td>0.8899</td>
</tr>
<tr>
<td>W2SLS</td>
<td>2.5103</td>
<td>0.7772</td>
<td>0.4371</td>
</tr>
<tr>
<td>3SLS</td>
<td>6.6401</td>
<td>1.6277</td>
<td>0.1037</td>
</tr>
</tbody>
</table>

Table 7.1: Pricing of unorthogonalised exchange rate over entire period

The SUR estimate and the 3SLS estimate are fairly close and are quite different to both of the 2SLS estimates. The similarity between the SUR estimate and the 3SLS estimate and their difference to the 2SLS estimate implies that there is contemporaneous correlation in the residuals of the equations. The difference between the 2SLS estimate and the W2SLS estimate implies the presence of heteroskedasticity. The difference between the SUR estimate and the 3SLS estimate could be due to heteroskedasticity or correlation between the exogenous variables and the error terms.

From these results it is possible to infer that there was contemporaneous correlation between the residuals over the period and heteroskedasticity was present. There is another problem to examine and that is the effect of August 1998, when the J.S.E. crashed and the Top40 Index lost 30% in one month. This point may unduly influence the results and since it was a once off, due to the emerging market crisis, if it does unduly influence the results it would be best to remove it from the sample as it does not contribute to explaining the normal relationship between shares and the R/$ exchange rate.
As can be seen by the difference in values between table 1 and table 2, the presence of the return for August 1998 has a large influence on the estimated lambda values. Although the estimated values for the pricing of the exchange rate change for each estimation method with August 1998 removed, the differences between the methods within each period remain fairly consistent, implying the while the presence of August 1998 has an impact on the values of the coefficients it does not have an impact on the structure of the error terms.

With August 1998 removed, none of the estimation methods provides a significant value for the pricing of exchange rate exposure, implying that there is no extra reward for increasing exposure to the exchange rate. This applies to the model where the exchange rate is taken as a factor and the Top40 Index captures the movement of another unspecified factor.

### 7.1.2 Total exposure

To examine the pricing of total exposure to the exchange rate the Top40 Index is regressed against the R/S exchange rate and the residuals of this regression replace the Top40 term in the two-index model. This equation is displayed in (7.21)

$$I'_{2t} = \gamma_0 + \gamma_1 I'_{1t} + \epsilon_t$$  \hspace{1cm} (7.21)
Where the prime notes that the indices have already been adjusted to have a mean of zero. The new Top40 Index is labelled $I_{2t}^*$.

The result of this regression for the period less August 1998 is given in the next table:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.0000</td>
<td>6.6421</td>
<td>0.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>R/$</td>
<td>0.0154</td>
<td>0.1225</td>
<td>0.1260</td>
<td>0.9000</td>
</tr>
</tbody>
</table>

Table 7.3: Regression of Top40 on R/$ exchange rate excluding August 1998

Ensuring that both of the indices have means of zero has no impact on the slope coefficient, but it does ensure that the intercept is zero. The relationship between the Top40 and the R/$ over the entire period is relatively weak, implying that orthogonalising the exchange rate will yield a pricing factor not largely different to that yielded by orthogonalising the Top40 Index. Using the three month t-bill as the risk free rate and the new orthogonalised Top40 series, (7.7) can be rewritten as (7.22)

$$r_{it} - \lambda_0 = \lambda_1 h_{it} + \lambda_2 h_{2t} + b_{1t} I'_{2t} + b_{2t} I^*_{2t}$$  \hspace{1cm} (7.22)

(7.22) was estimated in Eviews for each of the system regression methods previously mentioned. The results of these system regressions over the entire period are displayed in the following table:
Table 7.4: Pricing of total exchange rate exposure over entire period

<table>
<thead>
<tr>
<th>Method</th>
<th>$\lambda_{1}$</th>
<th>t-stat</th>
<th>p-value</th>
<th>$\lambda_{2}$</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUR</td>
<td>8.5439</td>
<td>2.1479</td>
<td>0.0318</td>
<td>7.6302</td>
<td>7.9753</td>
<td>0.0000</td>
</tr>
<tr>
<td>2SLS</td>
<td>3.3361</td>
<td>0.8661</td>
<td>0.3865</td>
<td>7.3562</td>
<td>3.5913</td>
<td>0.0003</td>
</tr>
<tr>
<td>W2SLS</td>
<td>5.1834</td>
<td>1.5288</td>
<td>0.1264</td>
<td>7.6114</td>
<td>4.3608</td>
<td>0.0000</td>
</tr>
<tr>
<td>3SLS</td>
<td>7.4128</td>
<td>1.8210</td>
<td>0.0687</td>
<td>7.3716</td>
<td>7.7133</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

$\lambda_{1}$ indicates the pricing of the market less the exchange rate effect, and it is definitely priced. The value of $\lambda_{2}$ is between 7.3 and 7.7 for each of the system methods. This implies that investors demanded a return of between 7.3% and 7.7% above the risk free rate for taking on market less exchange rate risk. $\lambda_{1}$ indicates the pricing of exposure to movements in the exchange rate. The values vary between the system methods but 3SLS indicates that investors received an extra 7.4% return for every unit increase in their portfolios exposure to the exchange rate. This number is close to $\lambda_{2}$, implying that exchange rate exposure was priced similarly to that of the market. A closer examination of the time period of the estimation reveals a possible reason for this unexpected result. As mentioned above, the entire period includes August 1998, when the Top40 Index dropped by nearly 30% in one month and the R/S depreciated by 5%. If this one month is treated as an outlier and excluded the following table shows the results of the system regression (August 1998 was also removed from the orthogonalising regression).
Chapter 7: Pricing of exchange rate exposure

Removing August 1998 gives table 7.5.

<table>
<thead>
<tr>
<th></th>
<th>$\lambda_1$</th>
<th>t-stat</th>
<th>p-value</th>
<th>$\lambda_2$</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUR</td>
<td>4.3626</td>
<td>1.1054</td>
<td>0.2690</td>
<td>10.5542</td>
<td>11.0817</td>
<td>0.0000</td>
</tr>
<tr>
<td>2SLS</td>
<td>-1.0634</td>
<td>-0.2732</td>
<td>0.7846</td>
<td>9.9574</td>
<td>5.2143</td>
<td>0.0000</td>
</tr>
<tr>
<td>W2SLS</td>
<td>1.1502</td>
<td>0.3368</td>
<td>0.7363</td>
<td>10.4606</td>
<td>6.3353</td>
<td>0.0000</td>
</tr>
<tr>
<td>3SLS</td>
<td>3.0339</td>
<td>0.7508</td>
<td>0.4528</td>
<td>10.3499</td>
<td>10.8247</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Table 7.5: Pricing of total exchange rate exposure over entire period excluding August 1998

The effect of August 1998 can again be clearly seen by comparing table 7.4 and table 7.5. The relationship between the results of the different regression methods for the period excluding August 1998 is roughly the same as the case where the Top40 was used to estimate the effect of another unspecified factor. This implies that the error terms have the same structure as when the Top40 was used to capture an unobserved factor. The pricing of the Top40 Index less the R/$ effect has increased, compared to the entire period, and remained significant. The pricing of the exchange rate has decreased with its standard error remaining roughly the same, this results in the exchange rate exposure becoming insignificant using even the most generous definitions of significance and the most beneficial assumptions with regards to the distribution of the error terms. This implies that over the entire period there was no extra reward for increasing total exposure to the exchange rate.

7.1.3 Incremental exposure

The above regressions have examined the pricing when no orthogonalisation takes place and when the Top40 is orthogonalised relative to the exchange rate. The only other option is to orthogonalise the exchange rate relative to the Top40. This would imply that one is examining the pricing of incremental exchange rate exposure. Equation (7.23) shows the relationship between the R/$ exchange rate and the Top40 that is estimated for each estimation method.
Chapter 7: Pricing of exchange rate exposure

\[ I'_t = \gamma_0 + \gamma_1 I'_t + \epsilon_t \]  

(7.23)

Where the prime notes that the indices have already been adjusted to have a mean of zero. The new R/S series is labelled \( I'_t \).

As noted above, the relationship between the Top40 and the R/S exchange rate was relatively weak over the whole period and this is seen by looking at the results of estimating (7.23) in table 7.6:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.0000</td>
<td>4.9911</td>
<td>0.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>TOP40</td>
<td>0.0087</td>
<td>0.0692</td>
<td>-0.1260</td>
<td>0.9000</td>
</tr>
</tbody>
</table>

Table 7.6: Regression of R/S exchange rate on Top40 excluding August 1998

As noted above a possible reason for the apparent weak relationship between the exchange rate and the Top40 could be due to instability of the relationship rather than a lack of association between Top40 movement and changes in the exchange rate.

(7.7) can now be rewritten as (7.24)

\[ r_t - \lambda_0 = \lambda_1 h_{1t} + \lambda_2 h_{2t} + h_1 I_{t'} + h_2 I_{t''} \]  

(7.24)

Where the three month t-bill rate is again used to estimate the risk free rate. Equation (7.24) was estimated for each of the system regression methods previously
As noted earlier, the presence of August 1998 has an undue influence on the pricing factors and this is seen again by comparing table 7.7 to table 7.8. The presence of August 1998 leads to underestimated pricing of the Top40 and overestimated pricing of the exchange rate.

The results seem to be robust with regards to which factor is orthogonalised, with 3SLS giving a pricing value of roughly 3 for each of the specifications. If the pricing for incremental exposure is the same as that of total exposure it implies that the exposure of the Top40 to the exchange rate was priced at the same rate as well. This indicates that investors would expect an extra return of 3% for every unit increase in exposure to the exchange rate. There is a caveat though, and this is that the pricing is not significant. This could be due to the market not expecting extra reward for increasing exposure to the exchange rate or it could be due to inconsistency in the pricing of exchange rate risk.
As noted in the literature review, a number of authors have indicated that a possible reason for the lack of significance for exchange rate exposure coefficients is the instability of that exposure. Applying this idea to pricing of exposure, it was decided to examine the stability of the pricing of exchange rate exposure. Since pricing is the extra return demanded for an increase in exposure, measured by a regression coefficient, one would expect the pricing of exchange rate exposure to change as the expectations for the exchange rate changed. As seen in the informal literature review, the Rand was viewed negatively until it turned at the end of 2001. The expectation was that the Rand would continue to depreciate and thus one would expect a positive number for the pricing of exposure to the Rand. The reasoning behind this idea is that the more a company profited from a Rand depreciation, the higher the companies return should be relative to a company that did not profit from a depreciation. It must be noted at this point that most Rand Hedges only gain in the short term from Rand depreciations. Their revenue increases relative to their costs, if the costs are based in South Africa, but this is typically only a short-term gain as depreciation leads to inflation and costs again rise. Thus for these companies to show returns that would be significantly higher than equivalent Rand neutral companies they would require consistent depreciation, this is exactly what happened until the end of 2001.

7.2 Is the pricing of R/$ exposure stable?

The Rand has gone through two distinct periods within the sample investigated. Up until the end of 2001 the Rand consistently depreciated beyond the depreciation implied by the difference in inflation between the U.S.A. and South Africa. One would expect that exposure would have been positively priced during this period as exporters and firms based overseas would consistently received returns that increased beyond their costs in South Africa purely as a result of the depreciation of the Rand. As noted earlier, exposure to the exchange rate within the Top40 is
widespread and investors would have reacted to this depreciation. After the end of 2001 the exchange rate appreciated and then remained relatively stable. During this period one would have expected exchange rate exposure to be priced negatively as overseas revenue would have decreased relative to domestic costs as a result of the exchange rate.

To test the stability of the pricing of the exchange rate the sample period is split in half. The first period is June 1996 to June 2001 corresponding to the period of Rand depreciation and the second period is July 2001 to June 2006, corresponding to the period of Rand strength and stability.

One has to be careful examining the pricing over these two distinct periods. If the exchange rate exposure is priced as suggested it is not necessarily an indication of future pricing, rather it is an indication of the length of time each phase of the Rand went through (depreciation, appreciation, stability) and the fact that over the period of the phase it was possible to increase returns by focusing on a specific category of shares (Rand Hedges or Rand Plays). This is only useful in the future if the Rand continues to experience long periods of consistent movement and it is possible to determine which phase the Rand is in. These assumptions are not necessarily practical and the analysis is more useful as an examination of past behaviour, with the belief that it may happen again, than of a guess as to the future pricing of the exchange rate.

The stability of the pricing of exchange risk is examined for each of the types of exchange rate risk examined above.
7.2.1 Stability of exchange rate pricing using R/$ and an unobserved factor

Table 7.9 and Table 7.10 give the pricing of exchange rate exposure for each of the estimation methods for the early and late period respectively using the exchange rate as an observed factor and the Top40 to capture an unobserved factor.

<table>
<thead>
<tr>
<th>1996.06-2001.06 excluding 1998.08</th>
<th>( \lambda_i )</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUR</td>
<td>13.6328</td>
<td>5.1400</td>
<td>0.0000</td>
</tr>
<tr>
<td>2SLS</td>
<td>16.1001</td>
<td>3.2644</td>
<td>0.0011</td>
</tr>
<tr>
<td>W2SLS</td>
<td>9.7603</td>
<td>2.5543</td>
<td>0.0107</td>
</tr>
<tr>
<td>3SLS</td>
<td>13.4712</td>
<td>5.3099</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Table 7.9: Pricing of unorthogonalised exchange rate exposure over early period excluding August 1998

<table>
<thead>
<tr>
<th>2001.07-2006.06</th>
<th>( \lambda_i )</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUR</td>
<td>-3.4624</td>
<td>-0.9866</td>
<td>0.3239</td>
</tr>
<tr>
<td>2SLS</td>
<td>-12.4436</td>
<td>-2.8795</td>
<td>0.0040</td>
</tr>
<tr>
<td>W2SLS</td>
<td>-7.3083</td>
<td>-1.9524</td>
<td>0.0510</td>
</tr>
<tr>
<td>3SLS</td>
<td>-7.4971</td>
<td>-2.0368</td>
<td>0.0418</td>
</tr>
</tbody>
</table>

Table 7.10: Pricing of unorthogonalised exchange rate exposure over late period

The values for \( \lambda \) in table 9 are all positive and significant, indicating that exchange rate exposure was definitely priced in the first period. Using the 3SLS estimate, an investor would have received more than 13\% more return above the risk-free rate for increasing the exposure to the exchange rate by one unit, which is admittedly a very large exposure. Nonetheless the exposure is both statistically and economically significant and positive over the first period.
Table 10 paints an entirely different picture. All of the estimation methods, with the exception of SUR, give significant negative pricing factors. SUR gives a negative estimate but it is not significant. This implies that over the second period investors were in fact penalised for increasing their exposure to the exchange rate. Again the pricing is both statistically and economically significant for most of the estimation methods but it is now negative. These tables show that the reason for the apparent lack of pricing over the sample period is that it contains two periods where there is significant pricing but in opposite directions.

7.2.2 Stability of pricing of total exchange rate exposure

Table 11 and table 12 display the results of the system estimation techniques when the Top40 is orthogonalised relative to the exchange rate.

<table>
<thead>
<tr>
<th></th>
<th>( \lambda_t )</th>
<th>t-stat</th>
<th>p-value</th>
<th>( \lambda_2 )</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUR</td>
<td>12.5272</td>
<td>4.5091</td>
<td>0.0000</td>
<td>21.2965</td>
<td>7.0877</td>
<td>0.0000</td>
</tr>
<tr>
<td>2SLS</td>
<td>17.6276</td>
<td>3.3146</td>
<td>0.0009</td>
<td>26.4854</td>
<td>3.4943</td>
<td>0.0005</td>
</tr>
<tr>
<td>W2SLS</td>
<td>11.4516</td>
<td>2.7986</td>
<td>0.0052</td>
<td>21.7019</td>
<td>3.8083</td>
<td>0.0001</td>
</tr>
<tr>
<td>3SLS</td>
<td>11.6957</td>
<td>4.3164</td>
<td>0.0000</td>
<td>20.3298</td>
<td>7.2300</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Table 7.11: Pricing of total exchange rate exposure over early period excluding August 1998

<table>
<thead>
<tr>
<th></th>
<th>( \lambda_t )</th>
<th>t-stat</th>
<th>p-value</th>
<th>( \lambda_2 )</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUR</td>
<td>-2.7506</td>
<td>-0.7769</td>
<td>0.4373</td>
<td>16.0145</td>
<td>2.4658</td>
<td>0.0000</td>
</tr>
<tr>
<td>2SLS</td>
<td>-8.9173</td>
<td>-2.0044</td>
<td>0.0452</td>
<td>18.2830</td>
<td>8.2365</td>
<td>0.0000</td>
</tr>
<tr>
<td>W2SLS</td>
<td>-5.0878</td>
<td>-1.3245</td>
<td>0.1855</td>
<td>15.8107</td>
<td>8.0262</td>
<td>0.0000</td>
</tr>
<tr>
<td>3SLS</td>
<td>-6.1880</td>
<td>-1.6799</td>
<td>0.0931</td>
<td>16.7704</td>
<td>12.7631</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Table 7.12: Pricing of total exchange rate exposure over early period excluding August 1998

Similarly to the situation where the Top40 is used to capture an unobserved factor
the values for $\lambda_i$ are all positive and significant in the first period and all negative in the second period. In this case all of the values for $\lambda_i$ are significant in the second period as well. This highlights the difference in returns that were rewarded for exposure to the exchange rate in the different periods. The values for $\lambda_2$ show an anomaly, the pricing for both periods is higher than the pricing over the entire period. This is due to the forced removal of TKG, INP and KMB from the sample for the earlier period due to a lack of data points.

### 7.2.2 Stability of pricing of incremental exchange rate exposure

Table 13 and table 14 show the results of each of the system equation techniques for the two periods when estimating the pricing of incremental exchange rate exposure.

<table>
<thead>
<tr>
<th>1996.06-2001.06 excluding 1998.08</th>
<th>$\lambda_1$</th>
<th>t-stat</th>
<th>p-value</th>
<th>$\lambda_2$</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUR</td>
<td>10.6936</td>
<td>3.9263</td>
<td>0.0001</td>
<td>6.5534</td>
<td>5.2332</td>
<td>0.0000</td>
</tr>
<tr>
<td>2SLS</td>
<td>17.2088</td>
<td>3.2926</td>
<td>0.0010</td>
<td>6.1568</td>
<td>1.6093</td>
<td>0.1077</td>
</tr>
<tr>
<td>W2SLS</td>
<td>11.6378</td>
<td>2.8806</td>
<td>0.0040</td>
<td>8.2039</td>
<td>2.7815</td>
<td>0.0055</td>
</tr>
<tr>
<td>3SLS</td>
<td>10.0694</td>
<td>3.8592</td>
<td>0.0001</td>
<td>6.5951</td>
<td>5.3001</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2001.07-2006.06</th>
<th>$\lambda_1$</th>
<th>t-stat</th>
<th>p-value</th>
<th>$\lambda_2$</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUR</td>
<td>-6.7989</td>
<td>-1.8914</td>
<td>0.0587</td>
<td>15.2329</td>
<td>30.8162</td>
<td>0.0000</td>
</tr>
<tr>
<td>2SLS</td>
<td>-13.1032</td>
<td>-3.0059</td>
<td>0.0027</td>
<td>15.7489</td>
<td>7.4109</td>
<td>0.0000</td>
</tr>
<tr>
<td>W2SLS</td>
<td>-8.9059</td>
<td>-2.3597</td>
<td>0.0184</td>
<td>14.3648</td>
<td>7.6771</td>
<td>0.0006</td>
</tr>
<tr>
<td>3SLS</td>
<td>-10.1779</td>
<td>-2.7241</td>
<td>0.0065</td>
<td>15.0119</td>
<td>31.3835</td>
<td>0.0060</td>
</tr>
</tbody>
</table>

Similarly to the other specifications with respect to orthogonalising the exchange rate, there is a notable difference between the pricing of the exchange rate for the
two periods. As with the total exposure to the exchange rate, all of the $\lambda_t$ values are negative and significant in the second period.

For each of the model specifications with respect to orthogonalisation there is a large difference between the pricing in the first period and the pricing in the second period. Typically positive (negative) exchange rate exposure was rewarded (penalised) for the first 5 year window and penalised (rewarded) during the second year window, unsurprisingly this matches the movement of the currency in those two periods with constant depreciation in the first period and rapid appreciation and stability in the second period.

### 7.3 Conclusions

The purpose of this chapter was to investigate the pricing of the exchange rate. Since some sectors of the economy benefit from R/$ depreciations and others from appreciations one would only expect the pricing of the exchange rate to be stable if the movements of the exchange rate are stable. This is not the case and the last ten years can be split into two distinct periods where the movement of the exchange rate is stable, in terms of direction at least, in each period and not between periods. It is found that within these two five-year periods exposure is significantly priced and the sign of the pricing, unsurprisingly, corresponds to the direction of the movement of the R/$ exchange rate within the period. This could be useful if the Rand were to enter a phase where a long period of depreciation/ appreciation is expected. Given the relatively high current account deficit and the fact that recently foreigners have been net sellers on the J.S.E. this would indicate that the Rand may be due for a correction, whether this will be a long term movement is unpredictable but if the market view is that it will be then the results of this chapter should be useful.
Chapter 8: Conclusions

In the previous chapters it has been shown that exchange rate exposure is more
wide-spread amongst South African shares than has generally been found in the
international literature. This is due to the model specification used to find exposure.
It was found that shares are more exposed to the contemporaneous return in the
Nominal R/$ exchange rate than any other exchange rate. The success in finding
exposure could also be due to the relatively large number of resource shares and
shares that are based overseas that are listed on the J.S.E.

It was shown that certain shares are consistently exposed to the exchange rate and it
is possible to \textit{a priori} estimate the sign of their exposure. Given the volatility of the
exchange rate, this raises a question as to whether it is possible to use this exposure
to protect against R/$ movement. The results of Chapter 6 show that it \textit{is} possible to
protect against R/$ depreciation by investing in shares listed on the J.S.E. The
advantage of the methods provided, compared with simply sending money abroad, is
the ability to both hedge against R/$ depreciation and to be able to participate in
South African growth. The methods examined were also robust with respect to
different expected exchange rate depreciations and different expectations for the
top40 Index.

Chapter 7 has shown that the R/$ exchange rate has gone through two distinct
phases in the last ten years and these were both long period movements. The fact
that the phases lasted for long periods is critical as it suggests that if it were repeated
it would be possible to outperform the Top40, which contains both Rand Hedges and
Rand Leverage shares, by hedging against movement in the right direction.

These results show that examination of shares’ exposure to the exchange rate is critical for optimal portfolio allocation.
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