THE RELATIONSHIP BETWEEN EXCHANGE RATE AND CONSTRUCTION COMPANY SHARE PRICES

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ABSTRACT

Exchange rate fluctuations are believed to affect the value of construction companies with foreign sales and/or operations for various economic reasons. The purpose of this research was to determine the relationship between both the Rand/US Dollar and Rand/Euro exchange rates, and the value of construction companies listed on the JSE Securities Exchange, using correlation analysis. The main finding of the research was that the Murray and Roberts share price is significantly positively correlated with the Rand/Euro exchange rate for weekly and monthly data (delayed response in the share price to exchange rate change). A weakening of the exchange rate in this case corresponded with an increase in the share price, several periods (weeks or months) later. This finding is of importance to investors and fund managers, looking for a Rand-hedge investment in the construction industry.

DECLARATION

I, Mark Neil van Druten declare that this research report is my own, unaided work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Mark Neil van Druten

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DEDICATION

This research report is dedicated to my parents, Neil and Charlene, and girlfriend, Lisa, to whom I am greatly indebted for their never ending patience, support and sacrifice throughout my MBA.

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1 INTRODUCTION

1.1 History and Background to the Problem

Exchange rate fluctuations are believed to change home currency revenues and the costs of companies with foreign sales and operations, and therefore affect the value of the company, for various economic reasons (Gao, 2000). Most JSE Securities Exchange (JSE) listed construction companies have foreign sales and operations and are involved in contracts outside of South Africa, typically in Africa, Europe or the Middle East. Most of these cross-border contracts are denominated in United States (US) Dollars or Euros. Therefore, these construction companies are believed to be exposed to exchange rate fluctuations as a result of their foreign activities. In a newspaper article by Jacks (2004) on construction group Aveng, it was stated that approximately 40% of Aveng's revenue was linked to the US Dollar and that the Rand's strength had made Aveng less competitive in international contracts.

As a result of this relationship and the economic reasons underpinning it, researchers have proposed that export–oriented companies, in general, should increase in value with a corresponding weakening of their home currency. This proposed relationship and direction of relationship has drawn attention to the construction industry in South Africa.

1.2 The Research Problem

1.2.1 Main Problem

The purpose of this study was to determine the direction and strength of the relationship between both the Rand/US Dollar and Rand/Euro exchange rates, and the value (share price) of JSE listed construction companies.

1.2.2 Sub-problems

- What was the direction and strength of the relationship between both the Rand/US Dollar and Rand/Euro exchange rates, and the value (share price) of individual JSE listed construction companies?
- What was the direction and strength of the relationship between both the Rand/US Dollar and Rand/Euro exchange rates, and the value of a construction index (equal weighted and market capitalisation weighted) representing JSE listed construction companies?

1.3 Rationale for this Research

The relationships between exchange rates and share prices have been investigated in numerous international studies and several South African studies. In almost all of the research conducted to date on this subject, researchers have used regression models, of various designs, to determine the sensitivity of the relationship between exchange rate changes and share price changes. In other words, the researchers have quantified the slope between these two variables. However, in order to use regression analysis researchers are making the implicit assumption of a causal link between the two variables, which may not be the case (Ajayi, Friedman & Mehdian, 1998).

In response to this, a limited amount of research has actually focussed on the causal links between exchange rates changes and share price changes using sophisticated statistical techniques and Granger causality tests. This research has focussed predominantly on country share price indices and the causal linkages between the variables.

This research has therefore taken a step back and does not assume a causal link between the variables but instead uses correlation analysis to investigate the direction and strength of a linear relationship between the variables. This research could therefore be seen as the first step in investigating relationships between variables, before the separate issue of causality is investigated and even before the sensitivity of the relationship between the two variables is

quantified through a regression model. In addition, although researchers have included construction companies in their design of stock indices and have analysed a series of individual companies from various industries, no research has focussed on the construction industry.

Bodie, Kane & Marcus (2002:162) defined hedging as: “Investing in an asset with a payoff pattern that offsets exposure to a particular source of risk”. Rand-hedge shares would enable investors to diversify some of the risk associated with exchange rate fluctuations. The aim of this research was to provide investors with empirical evidence on the Rand-hedge properties of JSE listed construction companies. Those companies that have exhibited a strong Rand-hedge relationship (against the US Dollar or the Euro) have been identified.

1.4 Delimitations and Limitations

1.4.1 Delimitations

- The scope of the study was limited to the following six construction companies listed under *Construction and Building Materials* on the JSE Securities Exchange (Business Day, 2003):

  Aveng
  Basil Read
  Concor
  Group 5
  Murray and Roberts
  WBHO

  No attempt was made to investigate construction companies on other securities exchanges. The study focused on data for the five-year period from the beginning of 1999 to the end of 2003.
- In addition, only the Rand/US Dollar and Rand/Euro exchange rates were considered. The analysis was therefore not extended to other

variables, which may or may not have been able to account for share price fluctuations.

- Daily, weekly and monthly data was used in the analysis. The relationships for quarterly data or even longer return intervals were therefore not captured in the analysis.

1.4.2 Limitations

- Share prices are typically influenced by many different variables, which were not captured in the analysis.
- Limited generalisations can be made to other industries and even construction companies in other countries, as the analysis performed was company specific and in the case of the construction indices, South Africa specific.

1.5 Assumptions

It was assumed that the data downloaded from the I-Net Bridge and BFA McGregor databases were accurate.

1.6 Subsequent Chapters of the Research Report

In the literature review (Chapter 2), which follows, related research and findings will be presented. This will help to place the current study in context and also help to formulate hypotheses. The methodology chapter, Chapter 3, will provide detail on the time series modelling and correlation analysis work that was conducted.

Time series modelling and cross-correlation results are presented in Chapter 4. The cross-correlation results are interpreted in Chapter 5 with reference to the hypotheses made in the literature review. Lastly, conclusions were drawn to summarise the overall findings of the research (Chapter 6).

2 LITERATURE REVIEW

The review starts with an introduction to exchange rate risk in general in Section 2.1. Research into exchange rate-company interactions or relationships (book value relationship, cash flow relationship, company value relationship) has focussed on the exposure or sensitivity of this relationship. The bulk of this 'exposure' research has focussed on the exchange rate-company value relationships, which are referred to as 'operating exposure' investigations. In these studies the sensitivity of the exchange rate-share price relationship was measured using regression techniques and the findings from this body of research are presented in Section 2.2.

The results of exchange rate-share price causality studies are presented in Section 2.3. In this body of research, the causal links and direction of links between these two variables has been investigated using sophisticated statistical techniques including Granger causality tests. Section 2.4 positions this research report in relation to the previous research undertaken to date. Hypotheses are developed in Section 2.5.

2.1 Introduction to Exchange Rate Risk: Exchange Rates and Company Economics

Jorion (1990) states that exchange rate risk has been an important consideration for management and investors as currency volatility can affect a company's performance and a company's value. Exchange rates are a major source of uncertainty as they are typically four times as volatile as interest rates and ten times as volatile as inflation rates (Jorion, 1990). The flexible exchange rate system and the volatility of exchange rates have created uncertainty and risk for firms operating in a global environment (Prasad & Rajan, 1995). Exchange rates can have a substantial effect on the profitability and value of multinationals as well as domestic firms engaged in international trade.

Movement in the exchange rate may:

(1) Affect future cash flows by altering the firm's economic and competitive conditions in the product and factor markets;

(2) Change the domestic currency value of cash flows from foreign operations; and

(3) Result in translation gains or losses when assets and liabilities of foreign subsidiaries are converted into domestic currency terms

(Prasad & Rajan, 1995:457).

Heckerman (1972) conducted research into the exchange risks of foreign operations using a present discounted value valuation technique of foreign income streams. Companies with foreign operations have assets, incur operating costs and receive revenues denominated in foreign currencies (Heckerman, 1972). The potential capital gains and losses were found to be very different from those measured by traditional accounting techniques, which ignored changes in the terms of trade. Companies that were based in the US and sold products in foreign countries were more exposed than companies, which supplied the foreign market from operations overseas (Heckerman, 1972).

In support of this, according to Flood & Lessard (1986), in order to assess a company's foreign exchange exposure, companies need to consider more than just the contractual items found on the balance sheet. Other items than need consideration include orders booked but not yet shipped and other future contractual requirements (Flood & Lessard, 1986). In addition, companies with no foreign operations and no foreign currency assets, liabilities or transactions can still be exposed to foreign currency risk (Adler & Dumas, 1984). Currency exposure depends on what you have at risk.

In 1975 (Shapiro, 1975) concluded that a company's exchange rate risk was dependant on the:

- distribution of sales between domestic and export markets;
- extent of the company's import competition in the domestic market;

- substitutability between local and foreign factors of production; and
- type of industry which the company operated in.

Therefore, exchange rates can affect a company's value in many ways but how does this effect translate into lower stock prices? According to the efficient market hypothesis (Fama, 1991), security prices fully reflect all available information and therefore a company's share price should reflect all available information including the exchange rate effects. Stock prices have been found to adjust efficiently to firm-specific information (Fama & French, 1989, in Fama, 1991).

Kim & McElreath (2001) investigated exchange rate risk in the automobile industry. Companies such as Bayerische Motoren Werke (BMW) have production facilities in countries such as the USA and Mexico to counteract the strong Deutschemark and high labour costs in Germany and thereby reducing an automobile manufacturer's exchange rate exposure. If the currency weakens in a particular country versus say the Deutschemark, then the manufacturer can shift a larger proportion of the production there and increase exports to countries where the local currency has strengthened (Kim & McElreath, 2001).

Research undertaken by Christie & Marshall (2001) indicated that as a result of the introduction of the Euro in 1999, companies in the United Kingdom (UK) had experienced a reduction in foreign exchange uncertainty and currency exposure. This resulted from a reduction in the number of currencies, which the UK multinationals had to monitor and deal with. It was also found that the extent of the benefit from risk reduction varied between industries (Christie & Marshall, 2001).

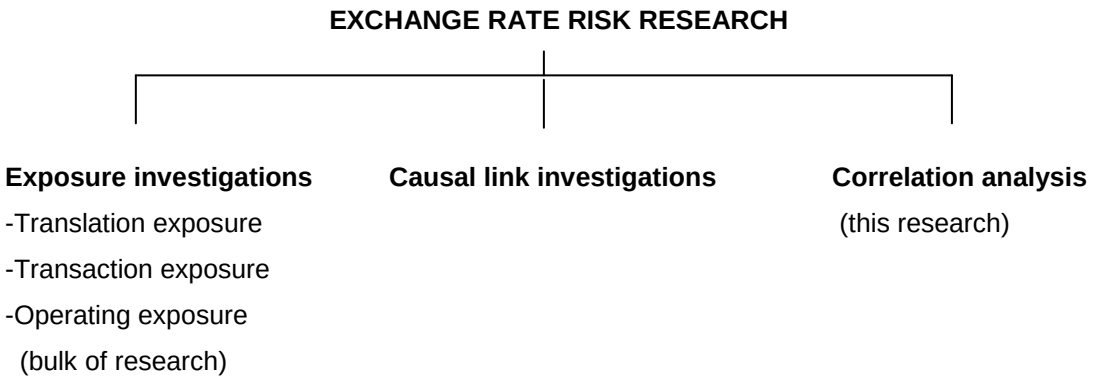
2.1.1 'Exposure' research in the context of exchange rate risk

The word exchange rate 'exposure' has been used extensively throughout the literature. Firstly it is important to bear in mind that there are different types of exchange rate exposure as will be detailed below. Secondly, in almost all the

literature, the word ‘exposure’ refers to the sensitivity of a relationship. In other words, these ‘exposure’ investigations have focussed on the sensitivity of the relationship between the two variables in a similar manner to calculating the slope between two variables.

In addition, exchange rate-share price causal investigations and exchange rate-share price correlation analysis investigations are also subsets within the more general exchange rate risk field of research. Figure 2.1 provides a schematic of this and puts the various research fields in context. Operating exposure investigations will be covered in Section 2.2 and causal link investigations in Section 2.3.

Figure 2.1: Components of exchange rate risk research



2.1.2 Three types of exchange rate exposure

Loudon (1993:20) defines three forms of foreign exchange exposure, namely translation exposure, transaction exposure and operating exposure:

> Translation (or accounting) exposure is the **sensitivity** of home currency book values and accounting earnings to changes in exchange rates, arising from foreign currency investing and financing activities.
>
> Transaction exposure is the **sensitivity** of the home currency future settlement value of the firm’s existing contracts denominated in foreign currencies, to exchange rate changes.

> Operating exposure is the **sensitivity** of the home currency economic value of the firm to changes in exchange rates. It reflects the responsiveness of the price and cost competitiveness of firms to fluctuations in currency values.

Loudon (1993) states that translation and transaction exposure arise as a result of foreign currency denominated contracts. However, foreign exchange operating exposure can exist even if all transactions are in the domestic currency. For example, a tourist establishment will experience operating exposure since demand for its services will be related to tourist's domestic currency value. The establishment is exposed despite the fact that all inputs and outputs of the establishment are in the home currency (Loudon, 1993). In support of Loudon (1993), Choi & Prasad (1995) state that exchange rate changes affect operating cash flows and company values through translation, transaction and economic risk exposure. The exchange rate risks will not have the same effect on all firms. It depends on operating profiles, financial strategies and other company-specific variables.

It is apparent that construction companies in South Africa will be exposed to exchange rate risk particularly if they are involved in sizeable foreign contracts denominated in foreign currencies. A major source of this exposure would arise out of the long-term contracts, which the companies get involved in. A large construction project can take several years to complete and the project is typically awarded at a fixed price, which would have been calculated based on a fixed exchange rate.

2.2 Review of Operating Exposure investigations

Most research has focussed on 'operating exposure' investigations. Operating exposure research is convenient because it avoids the various exposure definitions described in Section 2.1.2 and focuses on the end result of a company's exposure: the effect on the share price. The share price should take into account the translation exposure, transaction exposure and

any other form of exposure, which a company opens itself up to because share prices are expected to adjust for all company specific information available. This accounts for the tremendous focus on operating exposure investigations.

2.2.1 Determinants and calculation of operating exposure

Operating exposure depends on the characteristics of the industry (Bodnar & Gentry, 1993, in Kim & McElreath, 2001) and firm specific operating activities (Jorion, 1990; Choi & Prasad, 1995). Operating exposure considers the firm's future revenues, costs and profits, which are not represented in current accounting statements (Flood & Lessard, 1986). The items change with changes in exchange rates depending on the competitive effect (depends on structure of markets) and the conversion effect (Flood & Lessard, 1986). The location of a company's physical assets does not have a significant affect on operating exposure and understanding or analysing a company's accounting statements is not sufficient to assess its operating exposure (Flood & Lessard, 1986).

Luehrman's (1989) research findings indicate that operating exposure also depends on the exchange rate-induced demand shifts and terms associated with competitor's re-optimisation in response to an exchange rate shock. Redhead (2000) goes on to talk about two sources of operating exposure risk namely consumer demand changes and changes in the competitiveness of domestic rivals as mentioned by Luehrman (1989). For example, an exchange rate movement could make holidays cheaper abroad and therefore affect domestic demand (Redhead, 2000). Alternatively, a competitor may import components or materials and an exchange rate movement may reduce the cost of these imports to give the competitor a cost advantage. In this way a firm may be indirectly exposed to foreign exchange risk even though it does not import or export goods or services (Redhead, 2000). It has been shown (Adler & Dumas, 1984, in Donnelly & Sheehy, 1995) that companies whose operations are entirely domestic can still be affected by exchange rates if their input prices, output prices or demand is influenced by currency movements.

Some company values will be negatively related to the value of the home currency, some positively related and some will not be related at all (Correia, Perman & Rees, 1993, in Donnelly & Sheehy, 1995).

The export orientation of an industry is a determinant of its exchange rate exposure in countries such as Japan and Canada but not in the USA (Bodnar & Gentry, 1993, in Donnelly & Sheehy, 1995). The exposure may be complicated by aspects such as the extent to which the company imports raw material (Bodnar & Gentry, 1993, in Donnelly & Sheehy, 1995). Companies with the highest foreign sales to total sales ratio normally exhibit the strongest relationship with the exchange rate (Donnelly & Sheehy, 1995).

According to Shapiro (Shapiro, 1996, in Kim & McElreath, 2001), managing operating exposure involves all the aspects of running a corporation such as financial, marketing, management, production and other aspects. Multinationals can however adjust their transaction exposure by using covering instruments such as hedging activities, which can reduce the correlation between stock prices and exchange rates (Jorion, 1990).

In further research, Moles & Bradley (2002b) investigated the impact of currency changes on the cash flows on non-financial UK companies taking into account direct transactional exposures as well as indirect competitive aspects using questionnaires. It was found that companies use either operational or financial hedging approaches or both to manage exchange rate risk. Operational hedging would include deciding on the location of production facilities, sourcing inputs, product nature/feature/scope, choice of markets and currency of debt. This is sometimes referred to as natural hedging and is seen as a long-term management approach (Moles & Bradley, 2002b). Financial hedging was found to be limited because not only was the future exchange rate uncertain but the underlying cash flows were uncertain too. A significant percentage of UK companies were found to use operational techniques to manage long-run exchange rate exposure (Bradley & Moles, 2002a).

Luehrman (1989) defines operating exposure as the derivative of firm value with respect to the exchange rate. This definition accommodates changes in risk, capitalisation rates and changes in expected cash flows. Similarly, Flood & Lessard (1986) state that operating exposure can be defined as the extent to which the value of the firm changes with a change in the exchange rate.

2.2.2 Operating exposure coefficients

Research in South Africa

Jordaan (1986) investigated the relationship between share returns and the Rand/US Dollar exchange rate in South Africa over the period 1983 to 1986 using regression analysis. Thirty mining shares, thirty financial shares and thirty industrial shares were randomly selected for the study. Only seventeen of the ninety shares were significantly correlated as determined by the size of the regression coefficients. In addition, the direction of the significant regression coefficients was unstable and so no further interpretation could be made. It was concluded that no statistically significant relationship existed between share returns and exchange rates.

Lumley (2002) investigated the relationship between the Rand/US Dollar exchange rate and the value of resource companies listed on the JSE by calculating the direction and significance of the operating exposure regression coefficient of the resource companies on the Johannesburg Stock Exchange. This operating beta was calculated by regressing the share price returns against the exchange rate changes as many other researchers have done. No individual company had a significant positive operational beta over the 5-year, 1-year and 'last reporting periods' that were analysed (Lumley, 2002). Lumley (2002) stated that other factors had masked the exchange rate influence such as commodity price changes, which are not correlated with the Rand/US Dollar exchange rate.

Research in the United States

Jorion (1990) reported significant cross-sectoral differences in the exposure of multinationals in the USA. Firms with no foreign operations showed no measurable difference in operating exchange rate exposure despite the fact that they could still be exposed indirectly to exchange rate risk (Jorion, 1990). It was found that the operating exchange rate exposure is related to the fraction of total sales made overseas and this exposure was found to be significantly positively correlated with foreign sales (Jorion, 1990). Later work by Jorion (1991) indicates that industries that export a significant proportion of their sales, or have extensive foreign operations are significantly positively exposed and thus benefit from a depreciation of the US Dollar, which tends to increase their stock prices.

Bartov & Bodnar (1994) re-iterated that it was a common view that exchange rate movements affect the value of a company particularly if the company has a large proportion of foreign sales. The profitability and value of companies with foreign sales or operations were expected to increase with an unexpected depreciation of the local currency because the foreign currency cash flows translate into larger local cash flows (Bartov & Bodnar, 1994). There has been limited success in identifying significant correlations between simultaneous stock returns and US Dollar fluctuations in empirical research according to Bartov & Bodnar (1994), suggesting that researchers have included companies with limited linkages to international conditions including companies with exposures of opposite signs. Bartov & Bodnar (1994) also blame mispricing consisting of systematic errors by investors when trying to estimate the relationship between fluctuations in exchange rate and company value. This suggests that the stock prices take time to adjust. They proceeded to select companies, which were likely to have similar exchange rate exposures and examined lagged changes and contemporaneous changes in the US Dollar using quarterly data (60 trading day intervals) from 1978 to 1989. The regression model included a trade-weighted index of the US Dollar. Bartov & Bodnar (1994) found that the abnormal returns of these firms had no correlation with the contemporaneous change in the US Dollar but a lagged change in the US Dollar was a significant variable. They

interpreted this by stating that investors underestimate the impact and that the underestimation is generally only corrected when additional information that directly relates or explains the impact is available (Bartov & Bodnar, 1994).

Al Diab, Zoubi & Thornton (1994) used event study methodology to investigate the impact of changes in the US Dollar exchange rate on stock prices of multinational corporations in the US, which have substantial foreign operations. The researchers looked for very large changes in the exchange rate between the US Dollar and other major currencies (major foreign markets). The findings indicate that in general, the stock prices of multinationals are not significantly affected by changes in exchange rates unless the change is of very high magnitude (Al Diab *et al*, 1994). The researchers were unsure if exchange rates affect stock prices or vice versa (Al Diab *et al*, 1994).

Choi & Prasad (1995) investigated 409 multinationals in the USA for the period 1978 to 1989. Few industry portfolios exhibited significant operating exposure. Of the firms with significant operating exposure, 60% of the firms experienced an increase in share price and 40% experienced a drop in share price, with a depreciation of the US Dollar (Choi & Prasad, 1995). Firms in a given industry were heterogeneous in terms of operational and financial characteristics and therefore exposures differ even in the same industry (Choi & Prasad, 1995).

Chow, Lee & Solt (1997) state that short return horizons may not capture exchange exposure fully. Therefore it was proposed that long-horizon returns and long-horizon exchange rate changes provide a better estimate of exchange exposure. Research was conducted using a sample of US stocks that traded from 1977 to 1989. An exchange rate index was created as US dollars per unit of a basket of foreign currencies. Horizon lengths ranged from 1 month (short) to 48 months (long). A 1% shock in exchange rates (weakening US dollar) reduced earnings per share in the same year but increased earnings per share in the first and second year following the shock (Chow *et al*, 1997).

Miller & Reuer (1998) used a multiple exchange rate (currencies from major US trading partners) regression model to measure the operating exposure of company values in the US using 6 years of monthly data. It was found that the sign of the significant exposures varied within industries. Foreign direct investment was found to provide a local currency hedge whereas export intensity was not found to significantly affect exposures. 13% to 17% of US manufacturing companies were significantly exposed to foreign exchange rate movements.

Gao (2000) investigated the effect of unexpected exchange rate movements on the stock returns of 80 US manufacturing multinationals between 1988 and 1993 using monthly returns and focussing on company-specific data. Gao (2000:133) states:

> Theory predicts that an unexpected depreciation of the domestic currency will cause a positive abnormal return proportional to the firm's share of foreign sales in its total sales, and a negative abnormal return proportional to the firm's share of production located in foreign countries. The overall impact of exchange rate news is the sum of these two opposite effects and a residual effect.

The findings of this research support this theory. From the sample, for the average company with average foreign sales and average foreign production, the statistically significant results indicate that a 10% unanticipated depreciation of the dollar would lead to (Gao, 2000):

- a 6.9% increase in the abnormal stock return through foreign sales; and
- a 6.1% decrease in the abnormal stock return through foreign production.

Pantzalis, Simkins & Laux (2001) determined that US multinationals with foreign networks spread across many foreign countries were less exposed to currency risk than those with concentrated foreign networks. The presence of financial hedges, degree of foreign involvement, size of company, industrial

diversification and company risk were controlled for in the regression (Pantzalis *et al*, 2001).

Chan, Seow & Tam (2002) focussed their research on foreign exchange fluctuations (used exchange rate index) and the value of US pharmaceutical companies using data from 1990 to 1999. The industry was divided into proprietary producers (large exporters in general) and generic producers (much smaller companies with less of an export focus). The regression modelling indicated that proprietary drug producers were significantly negatively affected by an appreciating US Dollar during the 1990-1994 period but strangely significantly positively affected by an appreciating US Dollar during the 1995-1999 period (Chan *et al*, 2002). The reversal in exposure (contemporaneous research) was attributed to the increase in acquisition of foreign subsidiaries, which shifted costs to foreign currencies during the 1995 to 1999 period thereby matching costs with revenues (Chan *et al*, 2002). A one month lagged exchange rate effect was also discovered which resulted in significant sensitivities. No significant relationships were found for generic producers (Chan *et al*, 2002).

Bodnar & Wong (2003) discovered that estimates of exchange rate exposure depended on both the return horizon and model used. The research focussed on a sample of US companies over the period 1977 to 1996. Model structure was found to be a very important consideration as the construction of and inclusion of a market return variable has a large effect on the sign and size of exposures (Bodnar & Wong, 2003). This market portfolio return in the model is very important as it ensures that the exposure coefficients are not influenced by other correlated macroeconomic events. It was found that return horizons of over one month resulted in a higher percentage of statistically significant exposures as well as an increase in the magnitude of these exposures (Bodnar & Wong, 2003).

Research in other countries (excluding South Africa and the US)

Loudon (1993) investigated the foreign exchange operating exposure of Australian stocks during the period January 1984 to December 1989. The

sample consisted of 141 Australian companies covering a range of industries. It was found that only 6% of the sample companies had significant exposure coefficients (Loudon, 1993). There was strong evidence that resource stocks and industrial stocks respond differently. Resource stocks performed well when the currency depreciated and industrial stocks performed well when the currency appreciated (Loudon, 1993).

Research conducted on the German Stock Market for the period 1981 to 1989 indicated that construction and housing stocks had a positive exposure coefficient indicating gains from a depreciation of the Deutschemark although the exposure figures were not significant (Prasad & Rajan, 1995). The research indicated that export-oriented industries gained from a depreciation of the home currency and import-dominated industries gained from an appreciation of the home currency (Prasad & Rajan, 1995).

Donnelly & Sheehy (1995) conducted empirical research on a selection of companies in the UK that had at least 40% of the total sales in 1992 accounted for by foreign sales. A significant relationship was found between the exchange rate and the value of the portfolio of export-oriented companies (Donnelly & Sheehy, 1995). They also found evidence of a lagged response of share prices to exchange rate movements of several months (Donnelly & Sheehy, 1995).

He & Ng (1998) studied the foreign exchange exposure of Japanese multinational corporations (had to have at least 10% foreign sales) using data over the period 1979 to 1993. The analysis indicated that 25% of 171 Japanese multinationals had significant exchange rate exposure coefficients (contemporaneous relationship) suggesting that a depreciation of the Yen against other foreign currencies had a positive impact on the share returns of some Japanese multinationals (He & Ng, 1998). There was weak evidence of significant lagged exposures (He & Ng, 1998). Companies with extensive foreign activities had larger exchange rate exposures. The survey found that 41% of the corporations used derivatives to hedge their positions and that the

higher the hedging activity the lower the exchange rate exposure (He & Ng, 1998).

Glaum, Brunner & Himmel (2000) investigated the operating exposure of German corporations using daily data and 5-year sub-periods. A depreciation of the Deutschemark (DM) was expected to improve the position of German companies versus foreign competitors at home and abroad. However, the overall evidence of significant exchange rate exposures that support this argument was weak. It was found that the values of German companies were significantly affected by changes in the DM/US Dollar although the results were unstable over time (Glaum *et al*, 2000). In other words no consensus could be reached as to whether companies generally benefited or faired poorly under local currency appreciations or depreciations.

Di Iorio & Faff (2001) investigated the relationship between movements in both the Australian Dollar/Japanese Yen and Australian Dollar/US Dollar exchange rates and the returns of the Australian equities market for 24 industries of the Australian Stock Exchange using a regression analysis. The Australian equities market as a whole was found to be exposed to fluctuations in the Australian Dollar/Japanese Yen exchange rate in the longer term. There was a general increase in the number of statistically significant exchange rate return coefficients from a 1-day horizon to the 50-day horizon. However, an appreciation of the Australian Dollar was not found to have a positive effect on imports and a negative impact on exports (Di Iorio & Faff, 2001).

Joseph (2002) investigated the impacts of exchange rate changes on UK stock returns from 1988 to 2000 using regression analysis. The share returns were used to create equally weighted portfolios for industrial sectors. Approximately 33% of companies were significantly negatively affected by long-run foreign exchange rate appreciations compared with 28% over the short term (Joseph, 2002).

2.3 Review of Exchange Rate-Share Price Causality investigations

Abdalla & Murinde (1997) stated that there was no theoretical nor empirical consensus on the relationship between exchange rates and stock prices and that the causal direction had not been resolved. In addition, they recommended the use of correlation techniques, as they do not involve an implicit assumption of causality unlike regression analysis (Pindyck & Rubinfeld, 1991, in Abdalla & Murinde, 1997). According to Ajayi *et al* (1998), most of the research conducted in this field provides empirical evidence on the relation between stock returns and exchange rates but does not explore the issue of causality between the two variables. According to Ajayi *et al* (1998:242):

> The regression models used in previous studies have been based on implicit assumptions that some unspecified causal relations exist between stock returns and changes in exchange rates. However, the existence of such relations between the two variables and the directions of causality have not been rigorously established. Movements in the stock and currency markets may be related because of some underlying economic variables that systematically affect both markets leading to convergence of some expectations among market participants.

Abdalla & Murinde (1997) studied the exchange rate and stock price interactions in the emerging financial markets of India, Korea, Pakistan and the Philippines. The study focussed on the causal interactions between exchange rates and share prices using monthly data and real effective exchange rate changes. Econometric techniques and Granger-causality tests were used to investigate causal linkages. This methodology basically creates a white noise series and then calculates optimal lag lengths and causal links. The results indicate that there was a unidirectional link from exchange rates to stock prices in Korea, Pakistan and India. It was found that there was a unidirectional link from stock prices to exchange rates in the Philippines (Abdalla & Murinde, 1997).

Some researchers have suggested that changes in exchange rates affect income/output and therefore stock prices while others suggest that innovations in the stock market affect exchange rates through the capital account. Ajayi *et al* (1998) investigated the causal relations between stock returns and changes in exchange rates using pairwise Granger causality tests. The analysis was based on daily stock indices and exchange rate movements for a set of advanced and emerging countries. In the advanced economies, the direction of causality was found from stock returns to exchange rates. There was also evidence of a contemporaneous relationship between stock returns and changes in exchange rates in advanced economies. In emerging economies, no consistent causal relations were found. The different findings were attributed to structural differences between the advanced markets and developing markets (Ajayi *et al*, 1998).

Kwon & Shin (1999) investigated the response of stock prices to a range of macroeconomic fluctuations in Korea. The research indicates a relationship between, amongst other things, stock prices and foreign exchange rates. It was found that the stock prices lag behind changes in the macroeconomic variables and that macroeconomic variables are significant in predicting changes in stock prices.

Muradoglu, Taskin & Bigan (2000) investigated the causality between stock returns and macroeconomic variables in emerging markets using monthly data of nineteen emerging markets from 1976 to 1997. Macroeconomic variables included foreign exchange rates, inflation and interest rates and the researchers used country indices and not individual company stock values. According to Muradoglu *et al* (2000), most research has assumed that macroeconomic fluctuations influence stock prices and that this influence is unidirectional. In this research, Granger causality tests were used to indicate the precedence or predictive power among the various variables. Basically an equation is estimated, using regression, for the share returns, which contains various lagged macroeconomic variables. If any of the coefficients of these lagged macroeconomic variables are significant then conclusions can be drawn regarding causality (Muradoglu *et al*, 2000). The results indicated that:

- 12 out of 19 emerging markets exhibit some type of causal relationship between exchange rates and stock prices;
- 2 countries indicated bi-directional causality between stock returns and macroeconomic variables;
- 8 countries exhibited unidirectional causality from macroeconomic variables to stock returns; and
- 4 countries exhibited unidirectional causality from stock returns to macroeconomic variables.

2.4 The Research in the context of prior research

2.4.1 Alternative methodology to be used

In terms of the operating exposure research that was documented in Section 2.2, all nineteen studies used regression analysis to calculate the operating exposure coefficient. This coefficient indicates the sensitivity of a share price change to a unit change in exchange rate.

For example, Adler & Dumas (1984) state that operating exposure is best measured with statistical regression techniques. The regression coefficients will be in units of foreign currency. The technique divides the price into two parts: one is correlated with the exchange rate and the other is independent of the exchange rate (Adler & Dumas, 1984). The exchange rate exposure can be positive, zero or negative depending on the correlations between asset price and exchange rate (Adler & Dumas, 1984). If a researcher wants to determine the exposure to many currencies, then the regressions become multiple linear regressions (Adler & Dumas, 1984). Exposure is the regression coefficient when an assets local currency price is regressed on exchange rates (Adler & Dumas, 1984). The regression coefficient thus provides a single measure that summarises the sensitivity of the value of the firm to all the various ways in which exchange rate changes can affect it (Adler & Dumas, 1984).

Loudon (1993) also measured the exposure to be the slope coefficient relating to the currency variable in a time series multiple regression. Monthly stock returns and monthly values of the trade weighted index value of the Australian Dollar were used. In research conducted by Donnelly & Sheehy (1995) monthly abnormal returns were regressed on the returns of a sterling index. Jorion (1990) defined exposure as the sensitivity of the value of the firm to exchange rate randomness stating that it could be measured by the regression coefficient of the change in the value of the firm on the change in exchange rate (Jorion, 1990). Operating exposure does not imply causality and the exposure could just reveal the simultaneous impact of monetary factors on exchange rates and stock prices (Jorion, 1990).

However, researchers such as Abdalla & Murinde (1997) and Ajayi *et al* (1998) have disagreed with Jorion (1990) and stated that the regression models used in previous studies were based on an implicit assumption of an unspecified causal relationship. In terms of the causal link research that was documented in Section 2.3, all four studies used sophisticated statistical techniques and Granger causality tests to determine the direction of causality between the variables. The results were varied however most of the findings indicated a unidirectional link from exchange rates to stock prices. No research examined this causal link relationship in South Africa.

This research report uses correlation analysis to investigate the **direction** and **strength** of the linear relationship between exchange rates and share prices. This approach avoids the implicit assumption of a causal link and may be seen as a precursor to quantifying the slope of the relationship.

2.4.2 Applicability of existing research findings

Operating exposure research

The findings from the operating exposure research are applicable to this study because in order for an operating exposure coefficient to be statistically significant, the variable (typically share price) must be strongly correlated with the exchange rate. So a significant operating exposure coefficient implies a

strong correlation between the variables however this does depend to some extent on whether a linear regression or multiple linear regression was used. The research findings in the literature review are therefore considered applicable to this research report, which focuses on correlations analysis.

In general, the operating exposure research findings indicate that exchange rate risk exposure depends on the:

- portion of foreign sales (Shapiro, 1975; Jorion, 1990; Choi & Prasad, 1995);
- import competition in domestic market (Shapiro, 1975);
- substitutability between local and foreign factors of production (Shapiro, 1975);
- financial strategies (Choi & Prasad, 1995);
- company specific variables (Choi & Prasad, 1995);
- characteristics of the industry (Jorion, 1990); and
- foreign operations (Jorion, 1990; Choi & Prasad, 1995).

These determinants of operating exposure suggest that the correlation coefficients could vary across the construction industry in South Africa depending on the characteristics of each individual company. The amalgamation of a number of companies into an index such as a construction index could have the effect of moderating the size of the correlations as companies within the index have different characteristics and therefore may correlate differently with the exchange rates. According to Choi & Prasad (1995), industry groups include firms with positive and negative operating exposures. Therefore the aggregate of all the firms in an industry group, may exhibit an insignificant operating exposure coefficient despite the fact that individual firms exhibit significant operating exposure (Choi & Prasad, 1995). Mispricing was also evident and Bartov & Bodnar (1994) recommend investigating lagged changes in the response variable (share price). In addition, only a small percentage of companies have been found to exhibit significant operating exposure coefficients (Loudon, 1993; Bartov & Bodnar, 1994). There is also an indication that longer return intervals result in a higher percentage of significant exposure coefficients. For this reason, return

intervals of 1-day, 1-week and 1-month were analysed, and positive and negative lags of the response variable (share price or index price) were investigated.

Causal link research

The causal link research is inconclusive as to whether the direction of causality is from exchange rates to share prices or vice versa although most of the findings suggest a unidirectional exchange rate-share price causal link. To accommodate the range of causal interactions, both positive and negative lags of the response variable (share price or index price) will be analysed as stated above.

2.5 Hypotheses

Hypothesis 1: This hypothesis was to ascertain the direction and strength of a linear relationship between Rand/US Dollar exchange rate and the value (share price) of individual construction companies, for daily, weekly and monthly data.

H_0: $\rho = 0$ There is no relationship between Rand/US Dollar exchange rate and the value (share price) of individual construction companies, for daily, weekly and monthly data.

H_1: $\rho \neq 0$ There is a relationship between Rand/US Dollar exchange rate and the value (share price) of individual construction companies, for daily, weekly and monthly data.

Hypothesis 2: This hypothesis was to ascertain the direction and strength of a linear relationship between Rand/Euro exchange rate and the value (share price) of individual construction companies, for daily, weekly and monthly data.

H_0: $\rho = 0$ There is no relationship between Rand/Euro exchange rate and the value (share price) of individual construction companies, for daily, weekly and monthly data.

H_1: $\rho \neq 0$ There is a relationship between Rand/Euro exchange rate and the value (share price) of individual construction companies, for daily, weekly and monthly data.

Hypothesis 3: This hypothesis was to ascertain the direction and strength of a linear relationship between Rand/US Dollar exchange rate and the value of a construction index (equal weighted and market cap weighted) representing JSE listed construction companies, for daily, weekly and monthly data.

H_0: $\rho = 0$ There is no relationship between Rand/US Dollar exchange rate and the value of a construction index (equal weighted and market cap weighted) representing JSE listed construction companies, for daily, weekly and monthly data.

H_1: $\rho \neq 0$ There is a relationship between Rand/US Dollar exchange rate and the value of a construction index (equal weighted and market cap weighted) representing JSE listed construction companies, for daily, weekly and monthly data.

Hypothesis 4: This hypothesis was to ascertain the direction and strength of a linear relationship between Rand/Euro exchange rate and the value of a construction index (equal weighted and market cap weighted) representing JSE listed construction companies, for daily, weekly and monthly data.

H_0: $\rho = 0$ There is no relationship between Rand/Euro exchange rate and the value of a construction index (equal weighted and market cap weighted) representing JSE listed construction companies, for daily, weekly and monthly data.

H_1: $\rho \neq 0$ There is a relationship between Rand/Euro exchange rate and the value of a construction index (equal weighted and market cap weighted) representing JSE listed construction companies, for daily, weekly and monthly data.

In each case, the direction of any significant relationship was ascertained. Based on the underlying theory, a depreciation in the Rand (versus the US Dollar or Euro) should correspond with an increase in the share price or index value. The results were interpreted within this framework.

3 METHODOLOGY

In trying to determine the relationship between exchange rates and share prices there were two potential problems associated with simply regressing the share price (or index price) on exchange rates, namely:

1) The regression technique and methodology assumes causality which is not in any way justified (as discussed in Chapter 2); and
2) Any of the two variables could be related to time. This possible relationship with time could impact on the relationship between the two variables themselves. In much of the research presented in Section 2.2, researchers attempted to address this problem by adding variables into the regression equation such as a 'market' variable. Thus the relationship between the share price and the market was therefore removed and the remaining variability was not correlated with the general market movements.

In this research, these two problems were addressed as follows:

1) Correlation analysis was used instead of regression analysis thus negating the requirement to justify causality; and
2) The relationship between each of the two variables and time was removed by developing a Box-Jenkins ARIMA (Autoregressive/ Integrated/ Moving Average) model for every time series. This forecasting model removes the relationship between the exchange rate and time as well as between the share price or index and time. The actual time series modelling process that was undertaken is explained in Section 3.5.

   Most researchers have used a 'first difference' of the share price data and exchange rate data to remove the relationship between each of these two variables and time, see for example, Chan, Seow, & Tam (2002), Gao (2002), and Lumley (2000). In other words, the inputs into the regression models were 'changes in share prices' and 'changes in exchange rates'. This approach would have contributed to removing

the relationship between each variable and time although it has several shortcomings, since:

- there may still have been a relationship between the variable and time which the 'first difference' did not completely remove; and
- no steps were taken to verify whether the relationship between the variable and time had been completely removed.

The Box-Jenkins methodology for ARIMA modelling overcomes these shortcomings by providing a methodology, which systematically removes the relationship between each variable and time. The Box-Jenkins methodology for ARIMA modelling also provides a method for verifying whether the relationship between each variable and time has been completely removed. In fact, the 'first difference' as used by researchers such as Chan, Seow, & Tam (2002), Gao (2002) and Lumley (2000), is often only the first step in removing the relationship between each variable and time. In many instances a 'first difference' would be sufficient to remove the relationship with time. However without using the Box-Jenkins methodology for time series modelling, it cannot be confirmed whether a remaining relationship exists or not, between each variable and time.

3.1 Population and Sample

The research population is defined as being all of the construction companies listed within the JSE's "Construction and Building Materials" sector. This comprises six construction companies. All of these construction companies were analysed and thus formed part of the sample. The companies were individually analysed and collectively analysed (by designing two indices which represented the six construction companies in the form of an equal weighted index and a market capitalisation weighted index). For the Equal Weighted Construction Index, the returns for each of the six construction companies were given an equal weighting to calculate the value of this index. For the Market Weighted Construction Index, the returns for each of the six construction companies were weighted according to the market capitalisation of each company.

3.2 Research period

The research period is defined as the period from the beginning of 1999 to the end of 2003. Data was extracted for this five-year reporting period. If companies were not in operation for this full period, then the actual company life was used bearing in mind the statistical requirement of maintaining an adequate sample size.

3.3 Instrument design

Readily available data was accessed and therefore no questionnaires or other instruments were required.

3.4 Data collection

This process involved the following steps:

- The daily historical share price information for each of the six construction companies was downloaded from the I-Net Bridge financial database and BFA McGregor database for the period 1999 to the end 2003.
- The spot exchange rate data (Rand/US Dollar and Rand/Euro) was downloaded from the I-Net Bridge financial database and BFA McGregor database for the period 1999 to the end 2003.
- Data was visually checked for completeness using the two databases.
- Dividend adjusted share prices were used. Dividend information was downloaded from the BFA McGregor database and cross-checked with the dividends documented in the annual reports. The dividend adjustments were made on the 'ex-div' dates for each share price time series.
- It was important that the share price and exchange rate data were taken at a similar time of the day to facilitate an appropriate correlation investigation. Closing share price data was downloaded (JSE closes at approximately 17H00 each trading day). I-Net Bridge take the Rand/US Dollar exchange rate at 17H00 each day and the Rand/Euro exchange rate at 24H00 (midnight). BFA McGregor take both the Rand/US Dollar and Rand/Euro exchange rates at 16H05 daily. It was therefore decided that I-Net Bridge would be used for the Rand/US Dollar exchange rate and that BFA McGregor would be used for the Rand/Euro exchange rate.

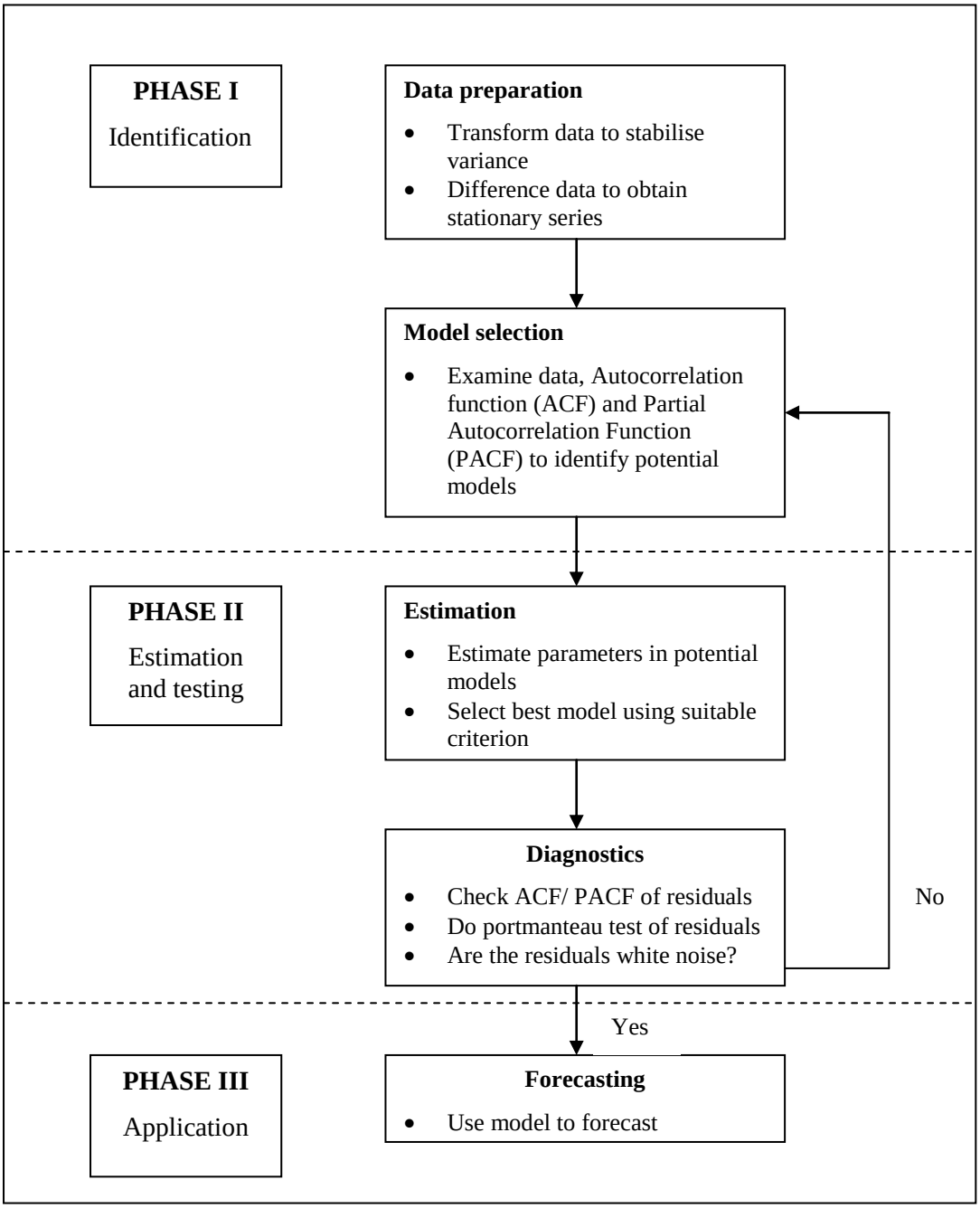
3.5 Development of Box-Jenkins ARIMA models and analysis of data

The NCSS software package was used to develop a Box-Jenkins ARIMA model for each time series. The Box-Jenkins ARIMA modelling methodology was used to:

a) Model the relationship between each company's share price and time (using historical data for the period 1999 to 2003)
b) Model the relationship between each Index and time (using historical data for the period 1999 to 2003)
c) Model the relationship between the Rand/US Dollar exchange rate and time (using historical data for the period 1999 to 2003).
d) Model the relationship between the Rand/Euro exchange rate and time (using historical data for the period 1999 to 2003)

Figure 3.1 on the following page provides a schematic representation of the Box-Jenkins methodology for time series modelling as described in Makridakis, Wheelwright and Hyndman (1998). This methodology was followed step by step however the models produced in this research were not used to forecast as stated in the final step in the Box-Jenkins methodology for ARIMA models in Figure 3.1. In this research the models were used to isolate the error terms or residuals after the relationship between the response variable and time had been 'modelled out'.

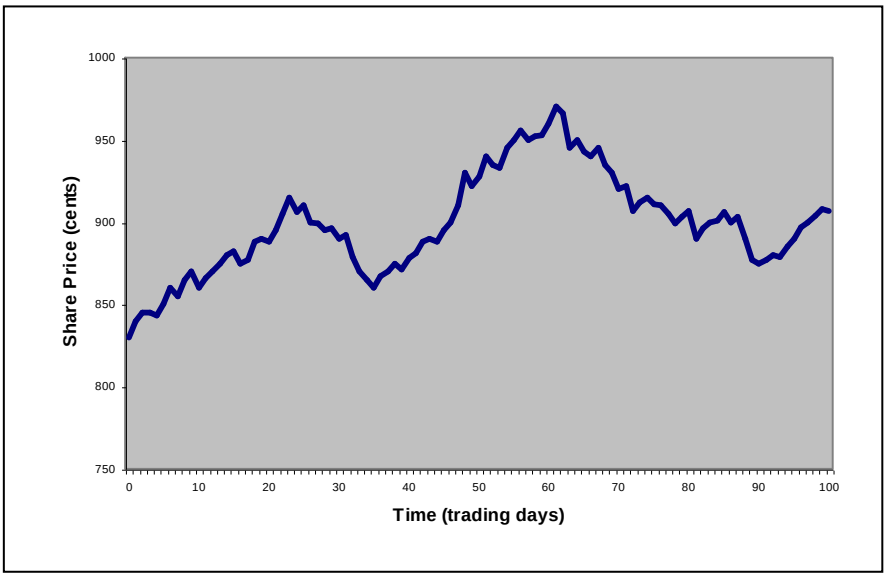
Figure 3.1: Schematic representation of the Box-Jenkins methodology for time series modelling as described in Makridakis *et al* (1998).



The relationship between each of the six share prices and the two indices, and time, was removed. In addition, the relationship between the Rand/US Dollar and Rand/Euro exchange rate, and time, was also removed. Thereafter, the share prices and indices (both with time removed) were correlated with the Rand/US Dollar and Rand/Euro exchange rates (time removed).

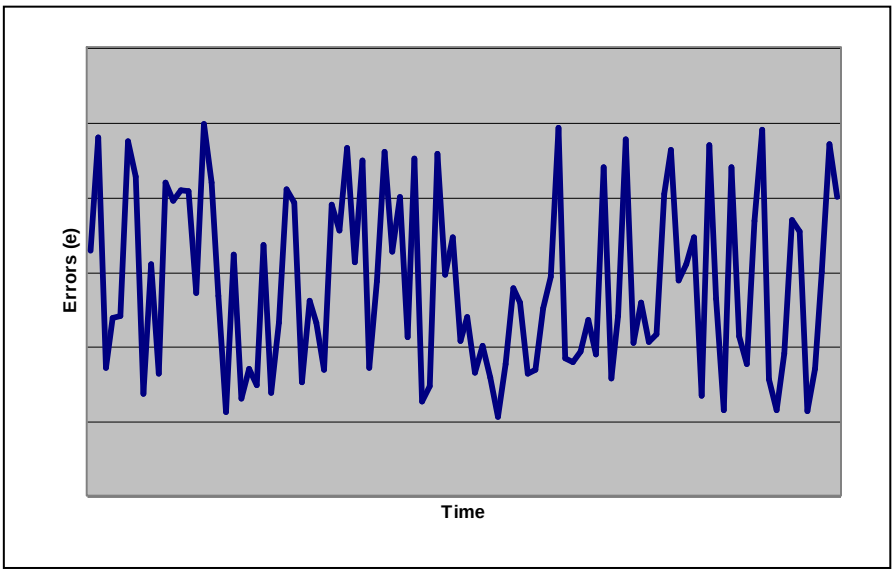
The process is best explained using a hypothetical example with diagrams. The share price data extracted for a particular company could look as follows:

Figure 3.2: Hypothetical example of relationship between Share Price and Time



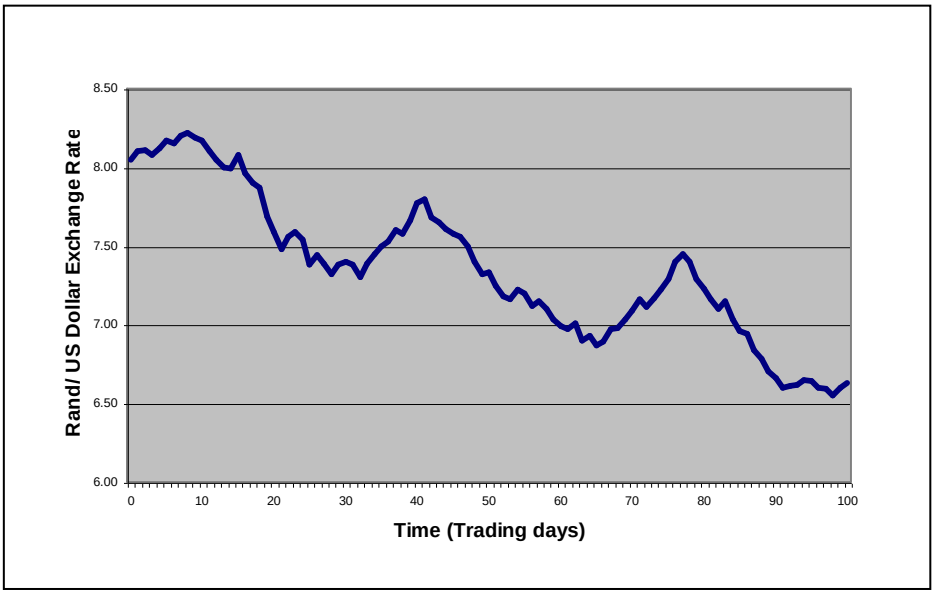
Once an appropriate Box-Jenkins ARIMA model is developed to model this time series, the error or residual terms may look as follows:

Figure 3.3: Hypothetical example of resulting White Noise after removing relationship between Share Price and Time



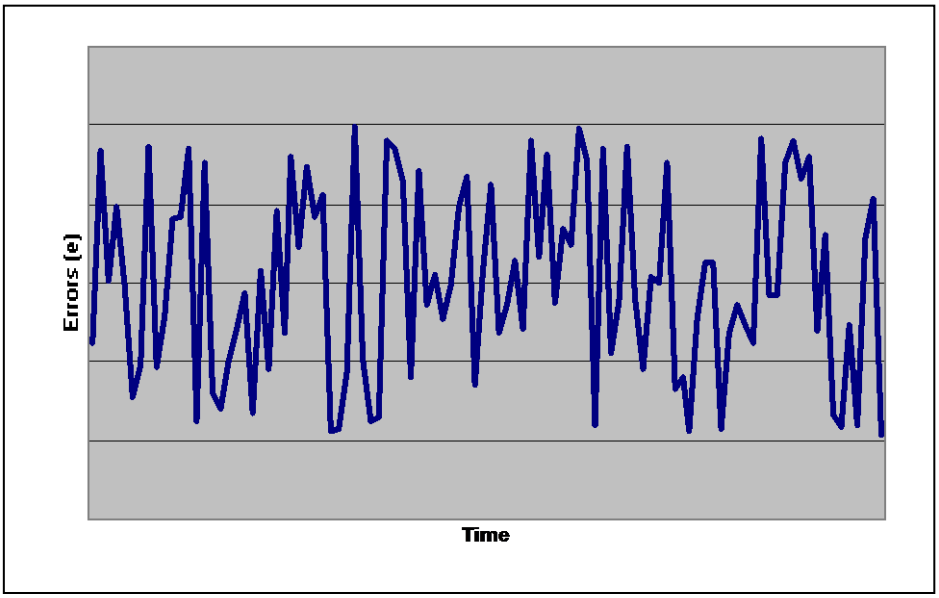
This modelling process would then need to be repeated for the exchange rate time series as well. The Rand/ US Dollar and time relationship may look as follows:

Figure 3.4: Hypothetical example of relationship between Exchange Rate and Time



Once an appropriate Box-Jenkins ARIMA model has been developed to model this time series, the error or residual terms could look as follows:

Figure 3.5: Hypothetical example of resulting White Noise after removing relationship between Exchange Rate and Time



The cross-correlation coefficient would then need to be calculated between the residuals or errors for the share price-time relationship and the residuals or errors of the exchange rate-time relationship for an appropriate investigation into the relationship between these two response variables.

In summary, the Box-Jenkins ARIMA model development and data analysis steps were as follows:

1. **Prepare Data**

   An ARIMA model cannot be applied to a data set until the data is both stationary in its variance as well as stationary in the mean. To stabilise data that is non-stationary in its variance, the data set was transformed using a suitable transformation. To stabilise data that is non-stationary in the mean, the data set was differenced to obtain stationary data (Makridakis *et al*, 1998).

2. **Model selection**

   The Autocorrelation Function as well as the Partial Autocorrelation Function were closely examined to identify particular patterns which assisted in determining which ARIMA model was most appropriate (Makridakis *et al*, 1998).

3. **Estimate parameters and evaluate choice of model**

   Once again the Autocorrelation Function as well as the Partial Autocorrelation Function were examined in order to estimate model parameters. This resulted in several potential models. These various models were compared and the optimum model was the one with the smallest Akaike's Information Criterion (AIC). The AIC figure does not have much meaning by itself and it is only useful for comparison purposes. A difference in AIC value of 2 or less was not regarded as substantial and as a result the simpler model or model with a better fit was usually chosen when AIC values were similar (Makridakis *et al*, 1998). In other words if the difference in AIC value was not substantial, then the model with the best residual behaviour was used.

4. Diagnostic checking

This involved studying the residuals after fitting the model to see if any pattern remained. There should be no pattern left and the residuals should be 'white noise'. This diagnostic check was performed by examining the ACF and PACF of the residuals. This is normally conducted by standardising the residuals so that they have a variance equal to one. A residual smaller than -3 or greater than 3 is an outlier and should be investigated. However, in this research a 5% significance level was used to identify outliers. Another test that was applied was the portmanteau test of residuals. This test helps determine if the residuals are white noise (Makridakis *et al*, 1998). In some cases, irrespective of the models investigated, the residuals were not white noise. In these cases the best model was used (model with best fit).

5. Cross-correlation coefficient

Once this entire process had been conducted for each share price time series, each index time series, the Rand/US Dollar time series as well as the Rand/Euro time series were the cross-correlations calculated. The direction and magnitude of each cross-correlation was then commented on.

6. Lagged cross-correlation coefficients

The share price or index residuals were also positively and negatively lagged by one, two, three, four and five return intervals and in each case, cross-correlated with the residuals from the exchange rates. These cross-correlation coefficients were examined to see if there was any indication of lagged share price or index responses to changes in the exchange rate

These six ARIMA modelling steps were repeated for daily data, weekly data and monthly data. The results are presented in Chapter 4, which follows.

4 RESULTS

Section 4.1 contains a description of the data sets that were used in the analysis including the results from the ARIMA modelling for all time series' under consideration. It is important to bear in mind that the ARIMA modelling was merely a tool used remove the relationship between each variable and time. The resulting time series residuals were then cross-correlated to determine the relationship between the two variables, which was the focus of this research. Time series data was available for the entire 5-year period from the beginning of 1999 to the end of 2003 for all companies and currencies except for Aveng, which only listed on 5th July 1999. The cross-correlations are presented in section 4.2 along with the acceptance of either the null hypothesis or alternative hypothesis for each relationship investigated.

In terms of the cross-correlations and the various lags, the cross-correlations were calculated between an independent variable (X_t) at time t and a dependent variable (Y_{t+k}) at time t. K is the lag or time index and it was allowed to be either positive or negative. The dependent variable Y_{t+k} (share price or index value) was cross-correlated with the independent variable X_t (exchange rate). A k value or lag of say +3 would mean that each exchange rate data point would be cross-correlated with a share price (or index) data point three periods ahead in time (used to account for delayed responses in the dependent variable).

4.1 Data Sets and ARIMA models chosen

Section 4.1.1 includes a description of the data and ARIMA modelling results for individual companies and associated currencies whilst section 4.1.2 includes a description of the data and ARIMA modelling results for the two indices that were constructed including the associated currencies.

4.1.1 Individual companies, exchange rates and ARIMA models used

Table 4.1: Individual company data, exchange rates and ARIMA models used

DAILY DATA			
Company	**No. daily data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Aveng (AEG)	1122	5th Jul 1999 to 31st Dec 2003	(0,1,1)
Basil Read (BSR)	1246	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Concor (CNC)	1246	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Group 5 (GRF)	1246	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Murray & Roberts (MUR)	1246	4th Jan 1999 to 31st Dec 2003	(0,1,0)
WBHO (WBO)	1246	4th Jan 1999 to 31st Dec 2003	(1,1,0) logged
Exchange rate	**No. daily data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Rand/US Dollar	1246	4th Jan 1999 to 31st Dec 2003	(0,1,1)
Rand/Euro	1246	4th Jan 1999 to 31st Dec 2003	(0,1,0)
WEEKLY DATA			
Company	**No. weekly data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Aveng (AEG)	235	5th Jul 1999 to 31st Dec 2003	(0,1,0)
Basil Read (BSR)	261	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Concor (CNC)	261	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Group 5 (GRF)	261	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Murray & Roberts (MUR)	261	4th Jan 1999 to 31st Dec 2003	(0,1,0)
WBHO (WBO)	261	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Exchange rate	**No. weekly data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Rand/US Dollar	261	5th Jan 1999 to 31st Dec 2003	(0,1,1)
Rand/Euro	261	5th Jan 1999 to 31st Dec 2003	(1,1,2) logged
MONTHLY DATA			
Company	**No. monthly data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Aveng (AEG)	54	5th Jul 1999 to 31st Dec 2003	(0,1,0)
Basil Read (BSR)	60	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Concor (CNC)	60	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Group 5 (GRF)	60	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Murray & Roberts (MUR)	60	4th Jan 1999 to 31st Dec 2003	(0,1,0)
WBHO (WBO)	60	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Exchange rate	**No. monthly data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Rand/US Dollar	60	4th Jan 1999 to 31st Dec 2003	(0,1,0)
Rand/Euro	60	4th Jan 1999 to 31st Dec 2003	(1,1,0)

4.1.2 Indices, exchange rates and ARIMA models used

It is important to note that Aveng was listed on 5th July 1999 and so share price data for Aveng was not available for the entire 5-year period. Aveng is

the largest construction group in South Africa and the company should be included in any construction index that is constructed. The indices were therefore constructed with data from 5th July 1999 to 31st December 2003 to account for this and incorporate Aveng. Exchange rate data corresponding with the same period of time was therefore also used for the analysis.

Table 4.2: Indices, exchange rates and ARIMA models used

DAILY DATA			
Index	**No. daily data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Equal Weighted Index (EWI)	1122	5th Jul 1999 to 31st Dec 2003	(1,1,0)
Market Cap Weighted Index (MKWI)	1122	5th Jul 1999 to 31st Dec 2003	(1,1,0)
Exchange rate	**No. daily data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Rand/US Dollar	1122	5th Jul 1999 to 31st Dec 2003	(0,1,0)
Rand/Euro	1122	5th Jul 1999 to 31st Dec 2003	(0,1,0)
WEEKLY DATA			
Company	**No. weekly data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Equal Weighted Index (EWI)	235	5th Jul 1999 to 31st Dec 2003	(0,1,1)
Market Cap Weighted Index (MKWI)	235	5th Jul 1999 to 31st Dec 2003	(0,1,0)
Exchange rate	**No. weekly data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Rand/US Dollar	235	5th Jul 1999 to 31st Dec 2003	(1,1,0)
Rand/Euro	235	5th Jul 1999 to 31st Dec 2003	(1,1,2) logged
MONTHLY DATA			
Company	**No. monthly data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Equal Weighted Index (EWI)	54	5th Jul 1999 to 31st Dec 2003	(0,1,0)
Market Cap Weighted Index (MKWI)	54	5th Jul 1999 to 31st Dec 2003	(0,1,0)
Exchange rate	**No. monthly data points**	**Data period covered**	**ARIMA model used to isolate residuals**
Rand/US Dollar	54	5th Jul 1999 to 31st Dec 2003	(0,1,0)
Rand/Euro	54	5th Jul 1999 to 31st Dec 2003	(0,1,0)

4.2 Cross-correlation results

The cross-correlation results are presented for each of the six construction companies as well as the two construction indices. The results will include cross-correlations between the response variable (share price or index) and both the Rand/US Dollar and Rand/Euro exchange rates for daily, weekly and monthly data.

4.2.1 Individual Companies

Aveng

Table 4.3: Cross-correlations between the Aveng share price and both the Rand/US Dollar and Rand/Euro exchange rates for daily, weekly and monthly data.

Cross-correlations between daily AEG residuals and daily Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0585 (95% confidence level)

AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision	AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0138	No	Accept H_0	1	-0.0006	No	Accept H_0
-4	0.0384	No	Accept H_0	2	-0.0064	No	Accept H_0
-3	-0.0453	No	Accept H_0	3	0.0058	No	Accept H_0
-2	-0.0199	No	Accept H_0	4	-0.0367	No	Accept H_0
-1	-0.0218	No	Accept H_0	5	0.0104	No	Accept H_0
0	0.0421	No	Accept H_0				

Cross-correlations between daily AEG residuals and daily Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0585 (95% confidence level)

AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision	AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0010	No	Accept H_0	1	-0.0193	No	Accept H_0
-4	-0.0566	No	Accept H_0	2	0.0016	No	Accept H_0
-3	0.0445	No	Accept H_0	3	-0.0203	No	Accept H_0
-2	0.0043	No	Accept H_0	4	0.0360	No	Accept H_0
-1	-0.0058	No	Accept H_0	5	-0.0234	No	Accept H_0
0	-0.0160	No	Accept H_0				

Cross-correlations between weekly AEG residuals and weekly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1279 (95% confidence level)

AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision	AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0154	No	Accept H_0	1	0.0028	No	Accept H_0
-4	-0.0178	No	Accept H_0	2	-0.1278	No	Accept H_0
-3	-0.0260	No	Accept H_0	3	0.0485	No	Accept H_0
-2	0.0422	No	Accept H_0	4	0.1008	No	Accept H_0
-1	-0.1169	No	Accept H_0	5	-0.0179	No	Accept H_0
0	0.0380	No	Accept H_0				

Cross-correlations between weekly AEG residuals and weekly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1279 (95% confidence level)

AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision	AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0248	No	Accept H_0	1	-0.0604	No	Accept H_0
-4	-0.0223	No	Accept H_0	2	0.0133	No	Accept H_0
-3	0.0174	No	Accept H_0	3	0.0614	No	Accept H_0
-2	-0.0318	No	Accept H_0	4	0.0250	No	Accept H_0
-1	-0.0767	No	Accept H_0	5	0.0024	No	Accept H_0
0	0.0643	No	Accept H_0				

Cross-correlations between monthly AEG residuals and monthly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2667 (95% confidence level)

AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision	AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0375	No	Accept H_0	1	-0.0509	No	Accept H_0
-4	-0.0083	No	Accept H_0	2	0.0176	No	Accept H_0
-3	0.1048	No	Accept H_0	3	-0.0356	No	Accept H_0
-2	-0.0821	No	Accept H_0	4	0.0317	No	Accept H_0
-1	0.0568	No	Accept H_0	5	0.0503	No	Accept H_0
0	-0.1253	No	Accept H_0				

Cross-correlations between monthly AEG residuals and monthly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2667 (95% confidence level)

AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision	AEG lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.1217	No	Accept H_0	1	-0.0061	No	Accept H_0
-4	-0.0456	No	Accept H_0	2	0.1407	No	Accept H_0
-3	0.0002	No	Accept H_0	3	-0.0215	No	Accept H_0
-2	-0.0457	No	Accept H_0	4	0.0835	No	Accept H_0
-1	0.0176	No	Accept H_0	5	-0.0802	No	Accept H_0
0	-0.1275	No	Accept H_0				

Basil Read

Table 4.4: Cross-correlations between the Basil Read share price and both the Rand/US Dollar and Rand/Euro exchange rates for daily, weekly and monthly data.

Cross-correlations between daily BSR residuals and daily Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0024	No	Accept H_0	1	-0.0277	No	Accept H_0
-4	0.0024	No	Accept H_0	2	-0.0113	No	Accept H_0
-3	0.0170	No	Accept H_0	3	-0.0037	No	Accept H_0
-2	-0.0148	No	Accept H_0	4	-0.0174	No	Accept H_0
-1	-0.0114	No	Accept H_0	5	0.0256	No	Accept H_0
0	0.0119	No	Accept H_0				

Cross-correlations between daily BSR residuals and daily Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0012	No	Accept H_0	1	-0.0012	No	Accept H_0
-4	0.0351	No	Accept H_0	2	-0.0187	No	Accept H_0
-3	-0.0032	No	Accept H_0	3	-0.0090	No	Accept H_0
-2	0.0024	No	Accept H_0	4	0.0366	No	Accept H_0
-1	-0.0235	No	Accept H_0	5	0.0262	No	Accept H_0
0	-0.0098	No	Accept H_0				

Cross-correlations between weekly BSR residuals and weekly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0968	No	Accept H_0	1	0.0339	No	Accept H_0
-4	0.0464	No	Accept H_0	2	-0.0387	No	Accept H_0
-3	-0.0360	No	Accept H_0	3	0.0375	No	Accept H_0
-2	0.0112	No	Accept H_0	4	0.0217	No	Accept H_0
-1	-0.0280	No	Accept H_0	5	-0.0485	No	Accept H_0
0	-0.0399	No	Accept H_0				

Cross-correlations between weekly BSR residuals and weekly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0015	No	Accept H_0	1	0.0213	No	Accept H_0
-4	0.0352	No	Accept H_0	2	-0.0041	No	Accept H_0
-3	-0.0157	No	Accept H_0	3	0.0403	No	Accept H_0
-2	-0.0474	No	Accept H_0	4	0.0072	No	Accept H_0
-1	-0.0063	No	Accept H_0	5	0.0081	No	Accept H_0
0	-0.0352	No	Accept H_0				

Cross-correlations between monthly BSR residuals and monthly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0939	No	Accept H_0	1	0.0267	No	Accept H_0
-4	0.0406	No	Accept H_0	2	-0.0634	No	Accept H_0
-3	-0.0500	No	Accept H_0	3	0.1701	No	Accept H_0
-2	-0.1036	No	Accept H_0	4	0.1246	No	Accept H_0
-1	-0.0763	No	Accept H_0	5	0.0785	No	Accept H_0
0	-0.0740	No	Accept H_0				

Cross-correlations between monthly BSR residuals and monthly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	BSR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0453	No	Accept H_0	1	0.0792	No	Accept H_0
-4	0.1646	No	Accept H_0	2	-0.0344	No	Accept H_0
-3	-0.0390	No	Accept H_0	3	0.1854	No	Accept H_0
-2	-0.0602	No	Accept H_0	4	0.1454	No	Accept H_0
-1	0.0084	No	Accept H_0	5	0.0658	No	Accept H_0
0	-0.1839	No	Accept H_0				

Concor

Table 4.5: Cross-correlations between the Concor share price and both the Rand/US Dollar and Rand/Euro exchange rates for daily, weekly and monthly data.

Cross-correlations between daily CNC residuals and daily Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision	CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0316	No	Accept H_0	1	0.0310	No	Accept H_0
-4	-0.0230	No	Accept H_0	2	-0.0002	No	Accept H_0
-3	-0.0239	No	Accept H_0	3	-0.0353	No	Accept H_0
-2	0.0165	No	Accept H_0	4	-0.0022	No	Accept H_0
-1	-0.0361	No	Accept H_0	5	-0.0083	No	Accept H_0
0	-0.0422	No	Accept H_0				

Cross-correlations between daily CNC residuals and daily Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision	CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0288	No	Accept H_0	1	0.0060	No	Accept H_0
-4	-0.0753	Yes	Reject H_0	2	-0.0306	No	Accept H_0
-3	-0.0093	No	Accept H_0	3	-0.0005	No	Accept H_0
-2	-0.0397	No	Accept H_0	4	-0.0043	No	Accept H_0
-1	-0.0408	No	Accept H_0	5	-0.0386	No	Accept H_0
0	0.0195	No	Accept H_0				

Cross-correlations between weekly CNC residuals and weekly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision	CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0143	No	Accept H_0	1	-0.0761	No	Accept H_0
-4	0.0431	No	Accept H_0	2	-0.1372	Yes	Reject H_0
-3	0.0002	No	Accept H_0	3	0.0342	No	Accept H_0
-2	-0.0140	No	Accept H_0	4	-0.0894	No	Accept H_0
-1	0.0283	No	Accept H_0	5	0.0493	No	Accept H_0
0	-0.0555	No	Accept H_0				

Cross-correlations between weekly CNC residuals and weekly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision	CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0760	No	Accept H_0	1	-0.0652	No	Accept H_0
-4	0.0277	No	Accept H_0	2	-0.0671	No	Accept H_0
-3	0.0288	No	Accept H_0	3	-0.0430	No	Accept H_0
-2	-0.0247	No	Accept H_0	4	0.0271	No	Accept H_0
-1	-0.0346	No	Accept H_0	5	-0.0254	No	Accept H_0
0	-0.0463	No	Accept H_0				

Cross-correlations between monthly CNC residuals and monthly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision	CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.1449	No	Accept H_0	1	0.0495	No	Accept H_0
-4	0.1714	No	Accept H_0	2	0.0506	No	Accept H_0
-3	-0.1261	No	Accept H_0	3	0.0666	No	Accept H_0
-2	-0.0609	No	Accept H_0	4	0.1011	No	Accept H_0
-1	0.0154	No	Accept H_0	5	0.1619	No	Accept H_0
0	-0.1956	No	Accept H_0				

Cross-correlations between monthly CNC residuals and monthly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision	CNC lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0503	No	Accept H_0	1	0.0931	No	Accept H_0
-4	0.2536	Yes	Reject H_0	2	0.0549	No	Accept H_0
-3	-0.1079	No	Accept H_0	3	0.0205	No	Accept H_0
-2	0.0315	No	Accept H_0	4	0.2238	No	Accept H_0
-1	0.0164	No	Accept H_0	5	0.1694	No	Accept H_0
0	-0.2525	No	Accept H_0				

Group 5

Table 4.6: Cross-correlations between the Group 5 share price and both the Rand/US Dollar and Rand/Euro exchange rates for daily, weekly and monthly data.

Cross-correlations between daily GRF residuals and daily Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision	GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0206	No	Accept H_0	1	-0.0370	No	Accept H_0
-4	0.0059	No	Accept H_0	2	0.0347	No	Accept H_0
-3	0.0439	No	Accept H_0	3	-0.0152	No	Accept H_0
-2	-0.1224	Yes	Reject H_0	4	-0.0048	No	Accept H_0
-1	-0.0215	No	Accept H_0	5	-0.0217	No	Accept H_0
0	0.0111	No	Accept H_0				

Cross-correlations between daily GRF residuals and daily Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision	GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0025	No	Accept H_0	1	0.0046	No	Accept H_0
-4	0.0256	No	Accept H_0	2	0.0169	No	Accept H_0
-3	-0.0840	Yes	Reject H_0	3	0.0043	No	Accept H_0
-2	-0.0121	No	Accept H_0	4	-0.0326	No	Accept H_0
-1	-0.0537	No	Accept H_0	5	0.0136	No	Accept H_0
0	-0.0134	No	Accept H_0				

Cross-correlations between weekly GRF residuals and weekly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision	GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0130	No	Accept H_0	1	-0.0378	No	Accept H_0
-4	0.0391	No	Accept H_0	2	-0.0457	No	Accept H_0
-3	-0.0277	No	Accept H_0	3	0.0629	No	Accept H_0
-2	0.0544	No	Accept H_0	4	-0.0281	No	Accept H_0
-1	-0.0264	No	Accept H_0	5	-0.0654	No	Accept H_0
0	-0.0448	No	Accept H_0				

Cross-correlations between weekly GRF residuals and weekly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision	GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0879	No	Accept H_0	1	-0.0047	No	Accept H_0
-4	0.0506	No	Accept H_0	2	0.0237	No	Accept H_0
-3	0.0388	No	Accept H_0	3	0.0877	No	Accept H_0
-2	-0.0646	No	Accept H_0	4	-0.0540	No	Accept H_0
-1	0.0297	No	Accept H_0	5	-0.0233	No	Accept H_0
0	-0.0524	No	Accept H_0				

Cross-correlations between monthly GRF residuals and monthly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision	GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0311	No	Accept H_0	1	-0.2214	No	Accept H_0
-4	0.0246	No	Accept H_0	2	0.0166	No	Accept H_0
-3	-0.1389	No	Accept H_0	3	-0.0136	No	Accept H_0
-2	0.0724	No	Accept H_0	4	-0.0670	No	Accept H_0
-1	-0.0585	No	Accept H_0	5	0.0124	No	Accept H_0
0	0.0546	No	Accept H_0				

Cross-correlations between monthly GRF residuals and monthly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision	GRF lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0388	No	Accept H_0	1	-0.1266	No	Accept H_0
-4	0.1028	No	Accept H_0	2	0.0952	No	Accept H_0
-3	-0.2845	Yes	Reject H_0	3	0.0851	No	Accept H_0
-2	0.0810	No	Accept H_0	4	-0.0321	No	Accept H_0
-1	-0.0422	No	Accept H_0	5	-0.0192	No	Accept H_0
0	-0.0068	No	Accept H_0				

Murray and Roberts

Table 4.7: Cross-correlations between the Murray and Roberts share price and both the Rand/US Dollar and Rand/Euro exchange rates for daily, weekly and monthly data.

Cross-correlations between daily MUR residuals and daily Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0028	No	Accept H_0	1	0.0127	No	Accept H_0
-4	-0.0284	No	Accept H_0	2	0.0139	No	Accept H_0
-3	-0.0061	No	Accept H_0	3	-0.0286	No	Accept H_0
-2	0.0188	No	Accept H_0	4	-0.0209	No	Accept H_0
-1	0.0077	No	Accept H_0	5	-0.0492	No	Accept H_0
0	-0.0154	No	Accept H_0				

Cross-correlations between daily MUR residuals and daily Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0115	No	Accept H_0	1	-0.0002	No	Accept H_0
-4	0.0205	No	Accept H_0	2	-0.0247	No	Accept H_0
-3	0.0214	No	Accept H_0	3	0.0157	No	Accept H_0
-2	-0.0033	No	Accept H_0	4	-0.0282	No	Accept H_0
-1	-0.0271	No	Accept H_0	5	-0.0312	No	Accept H_0
0	0.0118	No	Accept H_0				

Cross-correlations between weekly MUR residuals and weekly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0253	No	Accept H_0	1	-0.0218	No	Accept H_0
-4	0.0418	No	Accept H_0	2	-0.0349	No	Accept H_0
-3	-0.0520	No	Accept H_0	3	0.0229	No	Accept H_0
-2	-0.0087	No	Accept H_0	4	0.0712	No	Accept H_0
-1	-0.0886	No	Accept H_0	5	0.0022	No	Accept H_0
0	-0.0126	No	Accept H_0				

Cross-correlations between weekly MUR residuals and weekly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0584	No	Accept H_0	1	-0.0553	No	Accept H_0
-4	0.0095	No	Accept H_0	2	0.0200	No	Accept H_0
-3	-0.0279	No	Accept H_0	3	0.0442	No	Accept H_0
-2	-0.0176	No	Accept H_0	4	0.0027	No	Accept H_0
-1	-0.0612	No	Accept H_0	5	0.1271	Yes	Reject H_0
0	0.0381	No	Accept H_0				

Cross-correlations between monthly MUR residuals and monthly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0654	No	Accept H_0	1	-0.1612	No	Accept H_0
-4	0.0434	No	Accept H_0	2	0.1316	No	Accept H_0
-3	0.0684	No	Accept H_0	3	-0.1332	No	Accept H_0
-2	-0.2135	No	Accept H_0	4	0.1955	No	Accept H_0
-1	-0.0103	No	Accept H_0	5	-0.0940	No	Accept H_0
0	-0.0577	No	Accept H_0				

Cross-correlations between monthly MUR residuals and monthly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MUR lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.1260	No	Accept H_0	1	-0.1585	No	Accept H_0
-4	0.0824	No	Accept H_0	2	0.2441	No	Accept H_0
-3	0.0186	No	Accept H_0	3	-0.0061	No	Accept H_0
-2	-0.1432	No	Accept H_0	4	0.2835	Yes	Reject H_0
-1	-0.0550	No	Accept H_0	5	-0.2400	No	Accept H_0
0	0.0149	No	Accept H_0				

WBHO

Table 4.8: Cross-correlations between the WBHO share price and both the Rand/US Dollar and Rand/Euro exchange rates for daily, weekly and monthly data.

Cross-correlations between daily WBO residuals and daily Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision	WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0310	No	Accept H_0	1	-0.0328	No	Accept H_0
-4	-0.0269	No	Accept H_0	2	-0.0196	No	Accept H_0
-3	0.0159	No	Accept H_0	3	-0.0305	No	Accept H_0
-2	0.0421	No	Accept H_0	4	-0.0077	No	Accept H_0
-1	-0.0260	No	Accept H_0	5	0.0001	No	Accept H_0
0	-0.0146	No	Accept H_0				

Cross-correlations between daily WBO residuals and daily Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0555 (95% confidence level)

WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision	WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0264	No	Accept H_0	1	0.0003	No	Accept H_0
-4	0.0389	No	Accept H_0	2	-0.0377	No	Accept H_0
-3	0.0140	No	Accept H_0	3	-0.0105	No	Accept H_0
-2	-0.0051	No	Accept H_0	4	-0.0417	No	Accept H_0
-1	-0.0075	No	Accept H_0	5	-0.0026	No	Accept H_0
0	-0.0446	No	Accept H_0				

Cross-correlations between weekly WBO residuals and weekly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision	WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0155	No	Accept H_0	1	-0.1020	No	Accept H_0
-4	-0.0597	No	Accept H_0	2	-0.0493	No	Accept H_0
-3	-0.0582	No	Accept H_0	3	0.0432	No	Accept H_0
-2	-0.0609	No	Accept H_0	4	-0.0647	No	Accept H_0
-1	0.0031	No	Accept H_0	5	0.0230	No	Accept H_0
0	-0.0474	No	Accept H_0				

Cross-correlations between weekly WBO residuals and weekly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1213 (95% confidence level)

WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision	WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0220	No	Accept H_0	1	-0.0790	No	Accept H_0
-4	-0.0341	No	Accept H_0	2	-0.0540	No	Accept H_0
-3	-0.0990	No	Accept H_0	3	0.1008	No	Accept H_0
-2	-0.0097	No	Accept H_0	4	-0.0130	No	Accept H_0
-1	0.0291	No	Accept H_0	5	-0.0050	No	Accept H_0
0	-0.0765	No	Accept H_0				

Cross-correlations between monthly WBO residuals and monthly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision	WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0307	No	Accept H_0	1	-0.1275	No	Accept H_0
-4	-0.0625	No	Accept H_0	2	0.0233	No	Accept H_0
-3	0.0286	No	Accept H_0	3	-0.1762	No	Accept H_0
-2	-0.0950	No	Accept H_0	4	-0.0881	No	Accept H_0
-1	-0.0375	No	Accept H_0	5	0.0730	No	Accept H_0
0	-0.1675	No	Accept H_0				

Cross-correlations between monthly WBO residuals and monthly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2530 (95% confidence level)

WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision	WBO lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0720	No	Accept H_0	1	0.0146	No	Accept H_0
-4	0.0217	No	Accept H_0	2	0.0985	No	Accept H_0
-3	0.0765	No	Accept H_0	3	-0.1676	No	Accept H_0
-2	-0.0694	No	Accept H_0	4	-0.0885	No	Accept H_0
-1	-0.1134	No	Accept H_0	5	0.1434	No	Accept H_0
0	-0.2045	No	Accept H_0				

4.2.2 Construction indices

Equal Weighted Construction Index

Table 4.9: Cross-correlations between the Equal Weighted Construction Index (EWI) and both the Rand/US Dollar and Rand/Euro exchange rates for daily, weekly and monthly data.

Cross-correlations between daily EWI residuals and daily Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0585 (95% confidence level)

EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0248	No	Accept H_0	1	-0.0171	No	Accept H_0
-4	-0.0268	No	Accept H_0	2	0.0128	No	Accept H_0
-3	0.0099	No	Accept H_0	3	-0.0244	No	Accept H_0
-2	-0.0380	No	Accept H_0	4	-0.0279	No	Accept H_0
-1	-0.0384	No	Accept H_0	5	-0.0034	No	Accept H_0
0	0.0109	No	Accept H_0				

Cross-correlations between daily EWI residuals and daily Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0585 (95% confidence level)

EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0250	No	Accept H_0	1	-0.0002	No	Accept H_0
-4	-0.0142	No	Accept H_0	2	-0.0363	No	Accept H_0
-3	-0.0155	No	Accept H_0	3	0.0033	No	Accept H_0
-2	-0.0299	No	Accept H_0	4	-0.0147	No	Accept H_0
-1	-0.0613	Yes	Reject H_0	5	-0.0072	No	Accept H_0
0	-0.0100	No	Accept H_0				

Cross-correlations between weekly EWI residuals and weekly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1279 (95% confidence level)

EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0568	No	Accept H_0	1	-0.0295	No	Accept H_0
-4	0.0815	No	Accept H_0	2	-0.1349	Yes	Reject H_0
-3	-0.0735	No	Accept H_0	3	0.1282	Yes	Reject H_0
-2	0.0430	No	Accept H_0	4	-0.0220	No	Accept H_0
-1	-0.0862	No	Accept H_0	5	-0.0183	No	Accept H_0
0	-0.0358	No	Accept H_0				

Cross-correlations between weekly EWI residuals and weekly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1279 (95% confidence level)

EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0460	No	Accept H_0	1	-0.0463	No	Accept H_0
-4	0.0289	No	Accept H_0	2	0.0208	No	Accept H_0
-3	-0.0020	No	Accept H_0	3	0.0706	No	Accept H_0
-2	-0.0535	No	Accept H_0	4	-0.0182	No	Accept H_0
-1	-0.0381	No	Accept H_0	5	0.0305	No	Accept H_0
0	-0.0509	No	Accept H_0				

Cross-correlations between monthly EWI residuals and monthly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2667 (95% confidence level)

EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0875	No	Accept H_0	1	-0.1024	No	Accept H_0
-4	0.1002	No	Accept H_0	2	0.0712	No	Accept H_0
-3	-0.0677	No	Accept H_0	3	0.0218	No	Accept H_0
-2	-0.1425	No	Accept H_0	4	0.1097	No	Accept H_0
-1	-0.0109	No	Accept H_0	5	0.1332	No	Accept H_0
0	-0.1412	No	Accept H_0				

Cross-correlations between monthly EWI residuals and monthly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2667 (95% confidence level)

EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	EWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0397	No	Accept H_0	1	0.0270	No	Accept H_0
-4	0.1896	No	Accept H_0	2	0.1870	No	Accept H_0
-3	-0.1185	No	Accept H_0	3	0.0460	No	Accept H_0
-2	-0.0546	No	Accept H_0	4	0.1827	No	Accept H_0
-1	0.0038	No	Accept H_0	5	0.0902	No	Accept H_0
0	-0.2248	No	Accept H_0				

Market Capitalisation Weighted Construction Index

Table 4.10: Cross-correlations between the Market Capitalisation Weighted Construction Index (MKWI) and both the Rand/US Dollar and Rand/ Euro exchange rates for daily, weekly and monthly data.

Cross-correlations between daily MKWI residuals and daily Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0585 (95% confidence level)

MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0032	No	Accept H_0	1	-0.0017	No	Accept H_0
-4	0.0081	No	Accept H_0	2	0.0061	No	Accept H_0
-3	-0.0307	No	Accept H_0	3	-0.0180	No	Accept H_0
-2	-0.0053	No	Accept H_0	4	-0.0333	No	Accept H_0
-1	-0.0138	No	Accept H_0	5	-0.0213	No	Accept H_0
0	0.0211	No	Accept H_0				

Cross-correlations between daily MKWI residuals and daily Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.0585 (95% confidence level)

MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0088	No	Accept H_0	1	-0.0097	No	Accept H_0
-4	-0.0229	No	Accept H_0	2	-0.0174	No	Accept H_0
-3	0.0420	No	Accept H_0	3	-0.0103	No	Accept H_0
-2	-0.0068	No	Accept H_0	4	0.0063	No	Accept H_0
-1	-0.0270	No	Accept H_0	5	-0.0286	No	Accept H_0
0	-0.0070	No	Accept H_0				

Cross-correlations between weekly MKWI residuals and weekly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1279 (95% confidence level)

MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	-0.0278	No	Accept H_0	1	-0.0164	No	Accept H_0
-4	0.0127	No	Accept H_0	2	-0.1082	No	Accept H_0
-3	-0.0503	No	Accept H_0	3	0.0508	No	Accept H_0
-2	0.0218	No	Accept H_0	4	0.0960	No	Accept H_0
-1	-0.1188	No	Accept H_0	5	-0.0137	No	Accept H_0
0	0.0079	No	Accept H_0				

Cross-correlations between weekly MKWI residuals and weekly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.1279 (95% confidence level)

MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0156	No	Accept H_0	1	-0.0652	No	Accept H_0
-4	-0.0112	No	Accept H_0	2	0.0139	No	Accept H_0
-3	-0.0081	No	Accept H_0	3	0.0748	No	Accept H_0
-2	-0.0348	No	Accept H_0	4	0.0112	No	Accept H_0
-1	-0.0812	No	Accept H_0	5	0.0656	No	Accept H_0
0	0.0457	No	Accept H_0				

Cross-correlations between monthly MKWI residuals and monthly Rand/US Dollar residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2667 (95% confidence level)

MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.0526	No	Accept H_0	1	-0.1420	No	Accept H_0
-4	0.0189	No	Accept H_0	2	0.0842	No	Accept H_0
-3	0.0706	No	Accept H_0	3	-0.0966	No	Accept H_0
-2	-0.1517	No	Accept H_0	4	0.1167	No	Accept H_0
-1	0.0100	No	Accept H_0	5	-0.0073	No	Accept H_0
0	-0.1030	No	Accept H_0				

Cross-correlations between monthly MKWI residuals and monthly Rand/Euro residuals.
Large sample confidence limits = 1.96/square root (n) = ± 0.2667 (95% confidence level)

MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision	MKWI lag	Cross-corr.	Stat. Sig. at 5% level	Decision
-5	0.1427	No	Accept H_0	1	-0.0904	No	Accept H_0
-4	0.0402	No	Accept H_0	2	0.2200	No	Accept H_0
-3	-0.0209	No	Accept H_0	3	-0.0219	No	Accept H_0
-2	-0.0853	No	Accept H_0	4	0.1986	No	Accept H_0
-1	-0.0352	No	Accept H_0	5	-0.1355	No	Accept H_0
0	-0.0832	No	Accept H_0				

5 INTERPRETATION OF RESULTS

In terms of interpreting the cross-correlations, there were two points that needed to be borne in mind. Firstly, due to the export-orientation of construction companies in South Africa and the economic theory underpinning the relationship, a positive cross-correlation is anticipated. In other words, a negative cross-correlation does not make economic sense for this type of industry. However, irrespective of the direction of relationship, all significant cross-correlations will be highlighted and discussed. Secondly, also in terms of the economic theory underpinning the relationship, it is anticipated that any significant cross-correlation will be associated with a zero lag or a positive lag as the share price is expected to be dependant on the exchange rate. A delayed response of a share price, to a change in exchange rate, is a fairly common finding in the exchange rate exposure research. However, once again, any significant cross-correlation whether associated with a negative, zero or positive lag, will be discussed. It is important for the reader to bear this interpretive framework in mind as some of the results are therefore more 'expected' than others.

5.1 Cross-correlations for Individual Companies and Construction Indices, using Daily Data

Significant cross-correlations were found for:

- Concor (cross-correlated with Rand/Euro, negative relationship, lag –4, refer to Figure 5.1)
- Group 5 (cross-correlated with Rand/US Dollar, negative relationship, lag –2, refer to Figure 5.2)
- Group 5 (cross-correlated with Rand/Euro, negative, lag –3, refer to Figure 5.3)
- Equal Weighted Construction Index (cross-correlated with Rand/Euro, negative relationship, lag –1, refer to Figure 5.4)

Figures 5.1 to 5.4 illustrate the significant cross-correlations that resulted for each of these companies and indices. This information is merely a graphical

illustration of the pertinent cross-correlation data from Tables 4.3 to 4.10 in Chapter 4.

Figure 5.1: Cross-correlations of daily Concor residuals with daily Rand/Euro residuals, for various lags of the response variable (Concor residuals)

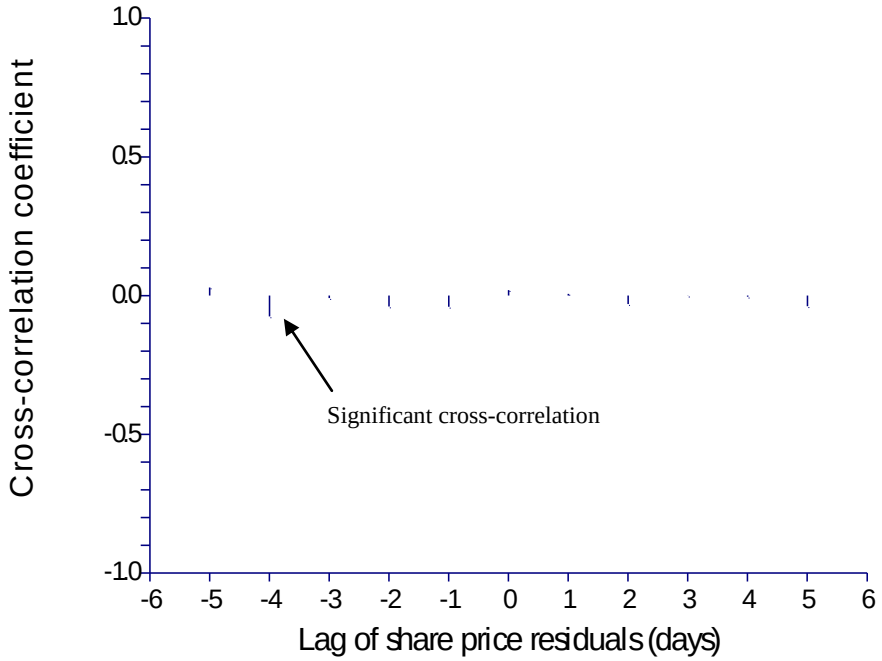


Figure 5.2: Cross-correlations of daily Group 5 residuals with daily Rand/US Dollar residuals, for various lags of the response variable (Group 5 residuals)

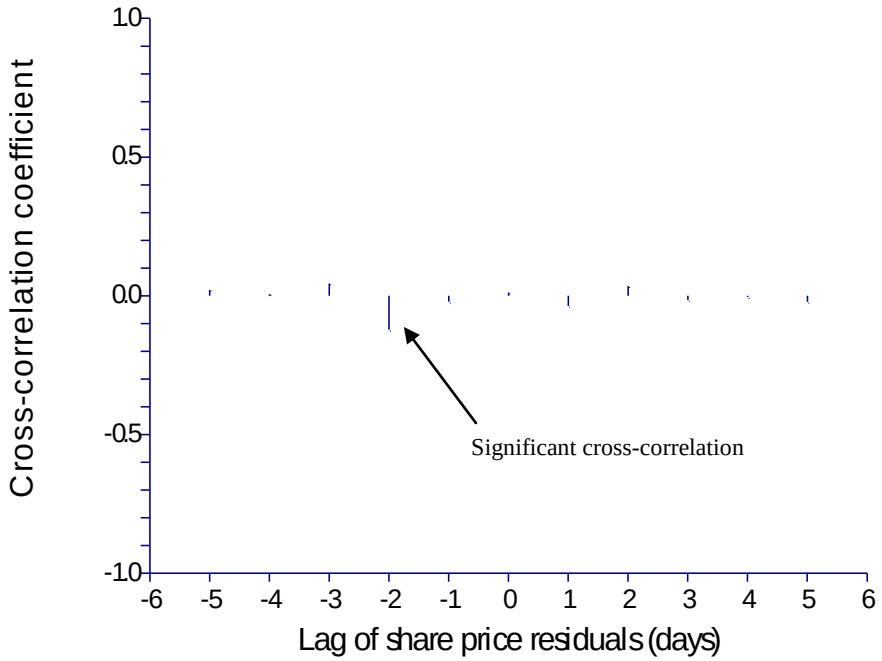


Figure 5.3: Cross-correlations of daily Group 5 residuals with daily Rand/Euro residuals, for various lags of the response variable (Group 5 residuals)

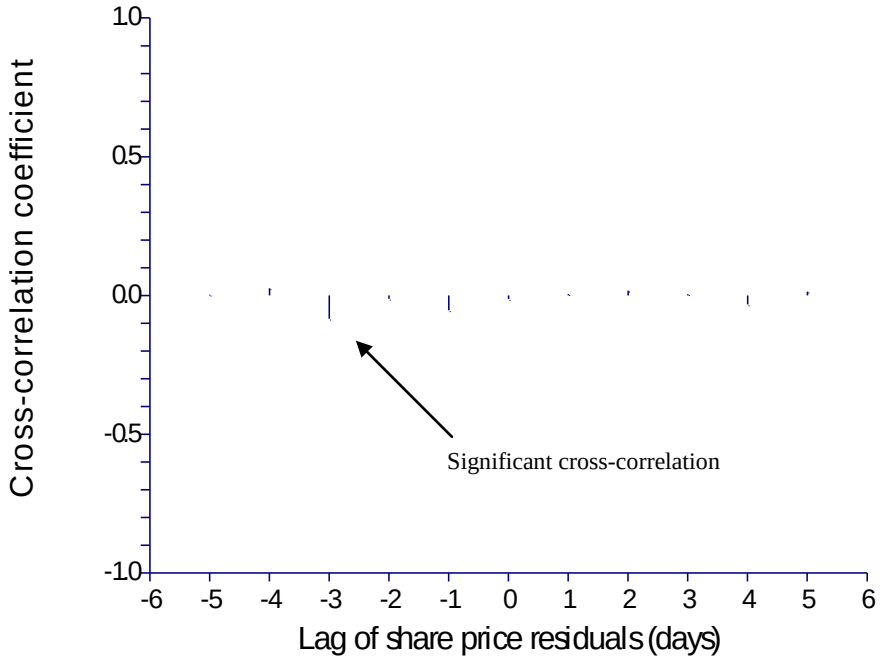
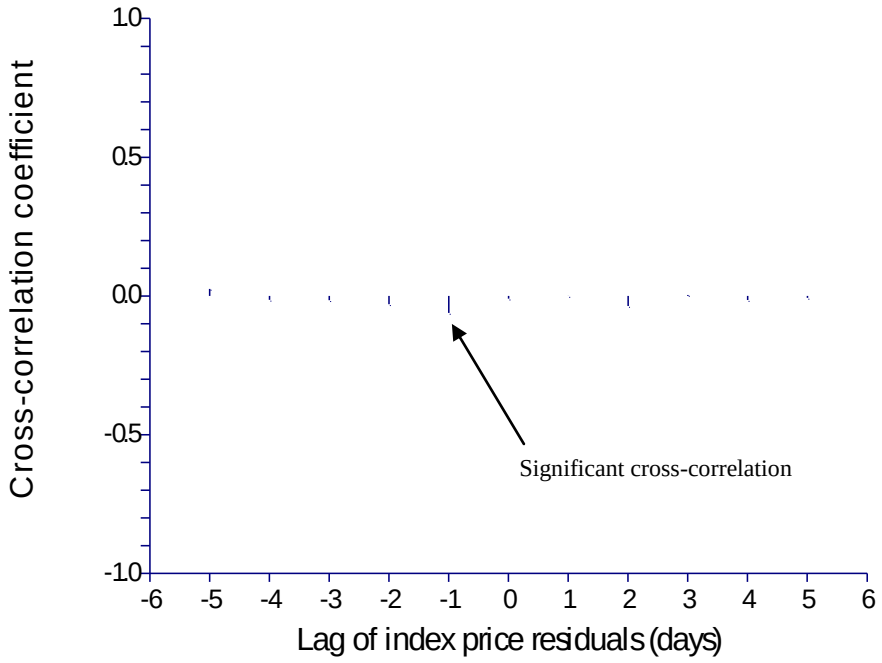


Figure 5.4: Cross-correlations of daily Equal Weighted Construction Index residuals with daily Rand/Euro residuals, for various lags of the response variable (Equal Weighted Construction Index residuals)



All four of these significant cross-correlations are of the opposite direction and opposite lag to what was reasonably expected in terms of the economic theory. For all four cases this relationship could be interpreted as: a share price or index appreciation (alternatively depreciation) corresponds with a strengthening exchange rate (alternatively weakening) several days later. It indicates that the share price change or share index change leads the exchange rate change.

In addition to discovering causal relationships from exchange rates to share prices, researchers (Abdalla & Murinde, 1997; Ajayi *et al*, 1998; Muradoglu *et al*, 2000) have discovered a limited number of causal relationships from share price changes to exchange rate changes for small, poorly integrated stock markets such as the Philippines Stock Market. It is therefore a remote possibility that share price changes could affect exchange rates. However, there is no research evidencing this relationship in South Africa.

In terms of the operating exposure research which has been conducted to date, researchers have had mixed success in detecting significant operating exposure coefficients and operating exposure coefficients of the correct direction for export-oriented companies. In addition, the length of the return interval appears to be an important component of the research design (Bodnar & Wong, 2003; Di Iorio & Faff, 2001) and longer return intervals have generally resulted in more significant operating exposure coefficients of the expected direction. It has been suggested that these longer return intervals allow investors to take into account the effect of exchange rate changes on a company's value and that this adjustment does not happen instantaneously. There is also the issue in South Africa of low liquidity. Some smaller companies in South Africa do not trade for a number of days and exhibit low liquidity. This could result in a company not being appropriately valued at a point in time.

In addition, with reference to Figures 5.1, 5.2, 5.3 and 5.4 is apparent that these significant cross-correlations are generally isolated and surrounded by cross-correlations of alternating sizes and directions at the adjacent lags,

which make the findings unconvincing. It is reasonable to expect that since the cross-correlations for say Concor at lag –4 is significant and negative (as discovered), that the cross-correlation at lag –3 and lag –5 would be the same direction and of similar magnitude. This is not the case. The Equal Weighted Construction Index correlations are better 'behaved' as the cross-correlations for adjacent lags (adjacent to lag –1) are also of the same direction but of small magnitude. However, for the same theoretical reasons proposed earlier, these four findings are considered to be a spurious statistic and no further interpretation can be derived from this result.

5.2 Cross-correlations for Individual Companies and Construction Indices, using Weekly Data

Significant cross-correlations were found for:

- Concor (cross-correlated with Rand/US Dollar, negative relationship, lag +4, refer to Figure 5.5)
- Murray and Roberts (cross-correlated with Rand/Euro, positive relationship, lag +5, refer to Figure 5.6)
- Equal Weighted Construction Index (cross-correlated with Rand/US Dollar, positive and negative relationship, lags +2 (negative) and +3 (positive), refer to Figure 5.7)

Figures 5.5 to 5.7 illustrate the significant cross-correlations that resulted for each of these companies and indices. This information is merely a graphical illustration of the pertinent cross-correlation data from Tables 4.3 to 4.10 in Chapter 4.

Figure 5.5: Cross-correlations of weekly Concor residuals with weekly Rand/US Dollar residuals, for various lags of the response variable (Concor residuals)

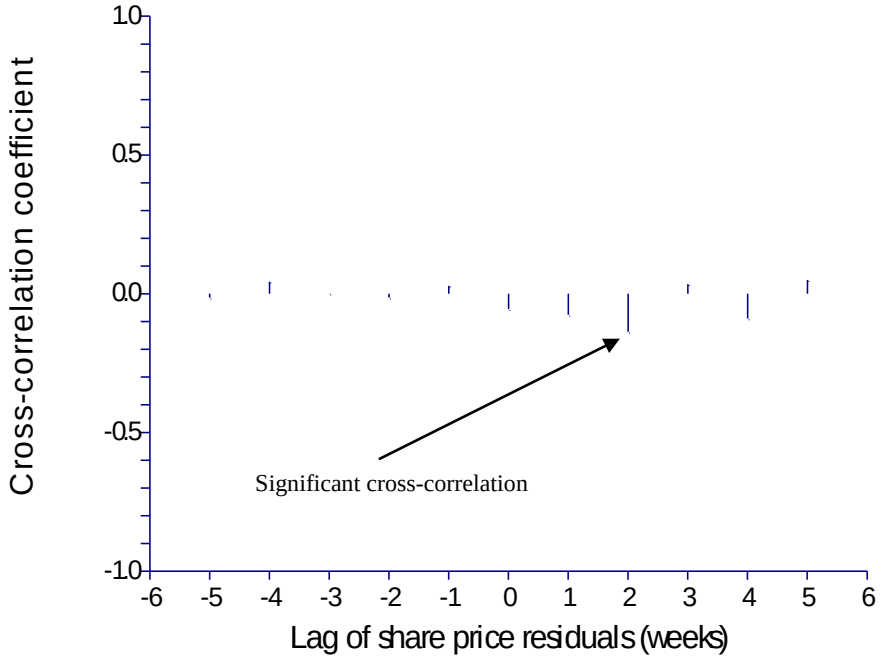


Figure 5.6: Cross-correlations of weekly Murray and Roberts residuals with weekly Rand/Euro residuals, for various lags of the response variable (Murray and Roberts residuals)

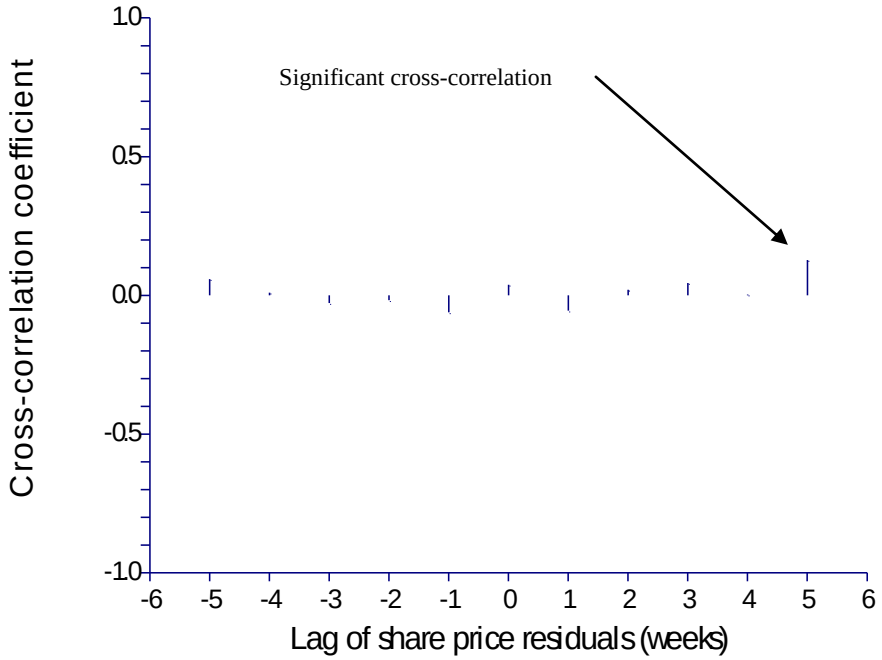
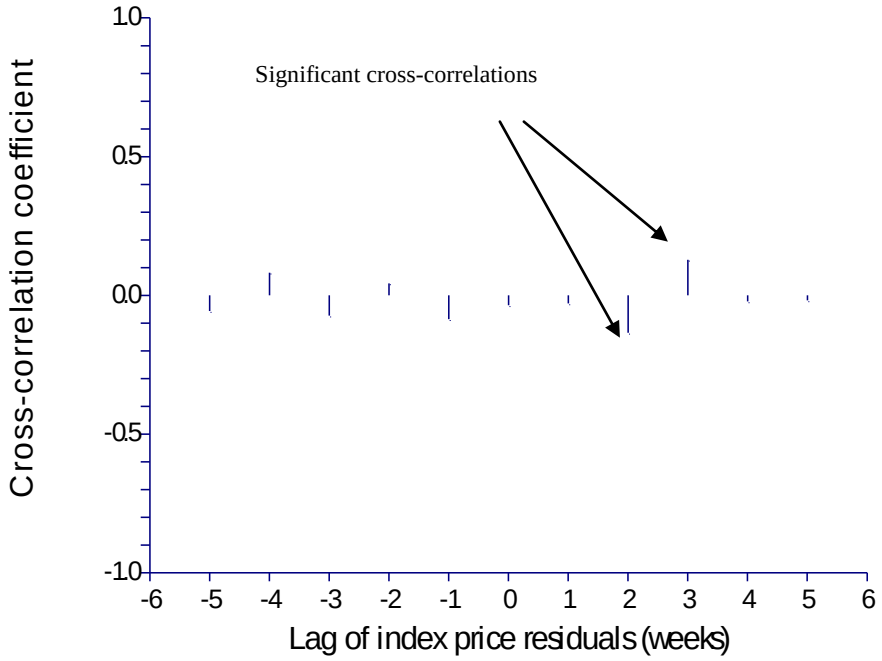


Figure 5.7: Cross-correlations of weekly Equal Weighted Construction Index residuals with weekly Rand/US Dollar residuals, for various lags of the response variable (Equal Weighted Construction Index residuals)



The results for Concor and the Equal Weighted Construction Index are unexpected and difficult to interpret. Concor's negative relationship is unexpected based on the expected reaction of an export-oriented company to exchange rate changes. The positive lag does indicate that an exchange rate change precedes a change in share price as expected. However, the negative relationship, change from a negative lag (daily data) to a positive lag (weekly data) combined with the change in relationship from a Rand/Euro correlation (daily data) to a Rand/US Dollar correlation (weekly data) suggest that the relationship could be a spurious statistic which occurred by chance.

The results for the Equal Weighted Construction Index are particularly unexpected as the significant correlation changes direction from negative (not anticipated for export-oriented industry) to positive after a one-lag change. The surrounding cross-correlations (surrounding lags +2 and +3) do not indicate any coherence with the significant cross-correlations. In addition, the significant cross-correlation for the Equal Weighted Construction Index with daily data indicated a negative correlation with the Rand/Euro exchange rate

(now correlated with Rand/US Dollar) and a negative lag (now positive lags). This inconsistency suggests that the result could be spurious.

The underlying theory supports the findings for Murray and Roberts of a positive cross-correlation with a positive lag. The company has been extensively involved in foreign contracts. Investors appear to be taking this exchange rate risk into account when valuing Murray and Roberts although there appears to be a lagged response from a change in exchange rates to a change in share price. This lagged positive response for export-oriented companies or multinationals has been researched extensively and significant lagged relationships have been discovered (Bartov & Bodnar, 1994; Donnelly & Sheehy, 1995; Chan *et al*, 2002). There is a chance that this result could not be spurious although a review of longer return intervals such as monthly returns could add more substance to this interesting result.

5.3 Cross-correlations for Individual Companies and Construction Indices, using Monthly Data

Significant cross-correlations were found for:

- Concor (cross-correlated with Rand/Euro, positive relationship, lag -4, refer to Figure 5.8)
- Group 5 (cross-correlated with Rand/Euro, negative relationship, lag -3, refer to Figure 5.9)
- Murray and Roberts (cross-correlated with Rand/Euro, positive relationship, lags +4, refer to Figure 5.10)

Figures 5.8 to 5.10 illustrate the significant cross-correlations that resulted for each of these companies and indices. This information is merely a graphical illustration of the pertinent cross-correlation data from Tables 4.3 to 4.10 in Chapter 4.

Figure 5.8: Cross-correlations of monthly Concor residuals with monthly Rand/Euro residuals, for various lags of the response variable (Concor residuals)

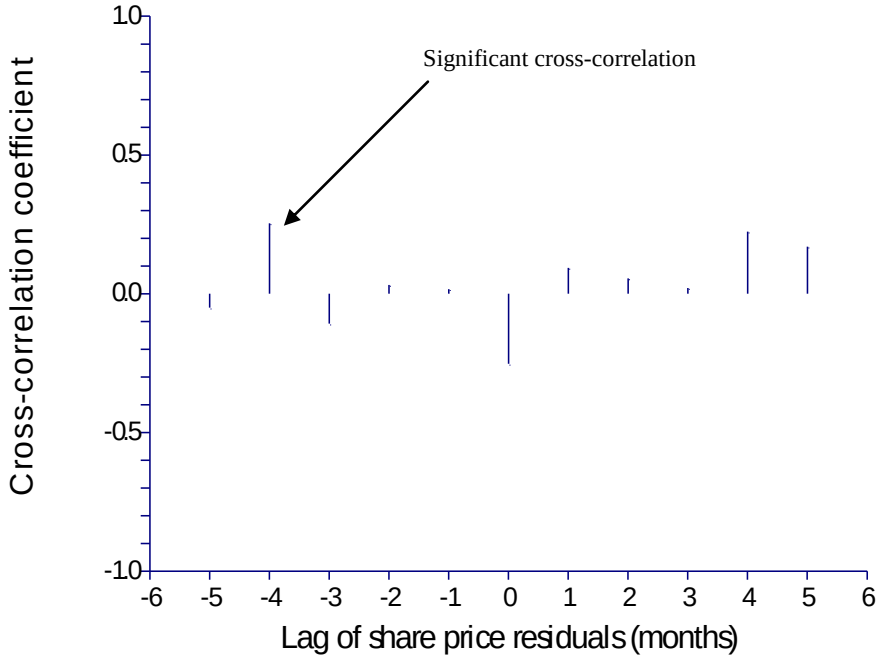


Figure 5.9: Cross-correlations of monthly Group 5 residuals with monthly Rand/Euro residuals, for various lags of the response variable (Group 5 residuals)

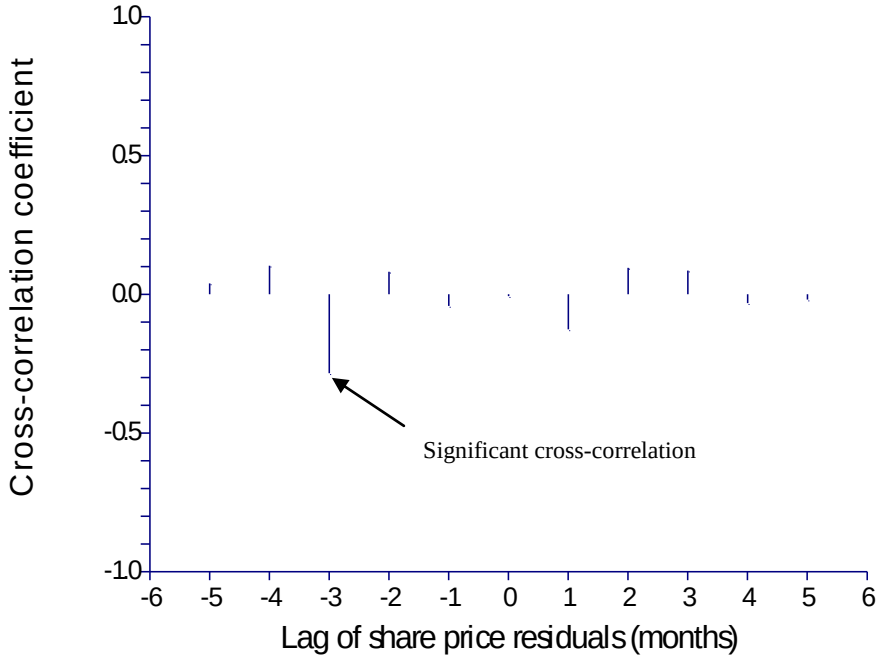
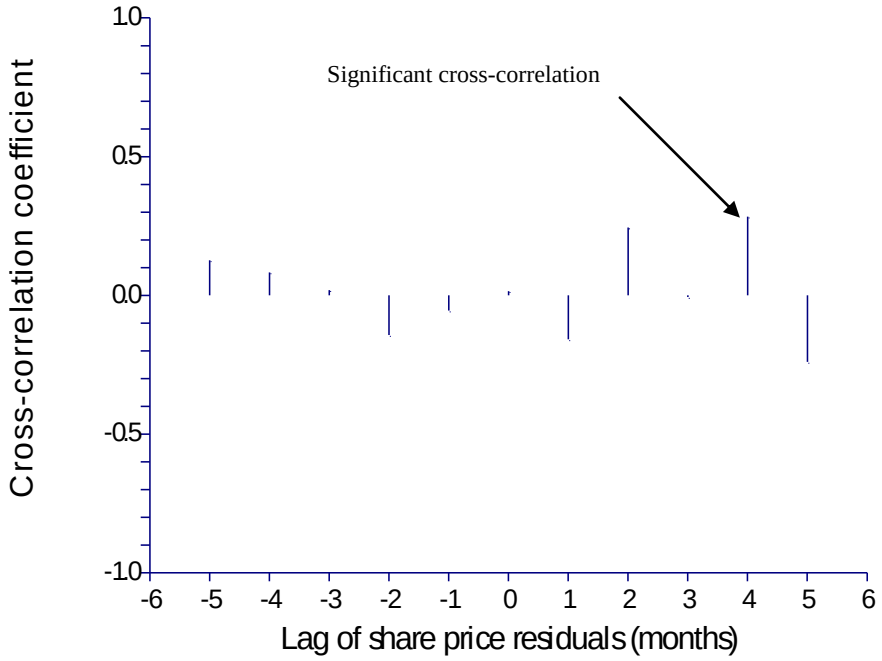


Figure 5.10: Cross-correlations of monthly Murray and Roberts residuals with monthly Rand/Euro residuals, for various lags of the response variable (Murray and Roberts residuals)



Once again the results for Concor and Group 5 are difficult to substantiate and understand. There appears to be little consistency in the results for Concor over the three return intervals that were considered in this research. Concor has demonstrated a negative correlation with a negative lag with the Rand/Euro exchange rate (daily returns), a negative correlation with a positive lag with the Rand/US Dollar exchange rate (weekly returns) and now a positive correlation with a negative lag with the Rand/Euro exchange rate (monthly returns). Figure 5.8 indicates a large negative cross-correlation at lag 0 and a large positive cross-correlation at lags +4 and +5 indicating an inconclusive range of results for the Concor time series. Therefore due to the lack of consistency of the Concor results over the three return intervals and the lack of substantiation for this current relationship, this cross-correlation is also considered to be a spurious statistic.

The Group 5 correlation has no theoretical basis as both the direction and lag of the cross-correlation are counter intuitive. The result indicates that there is a strong linear relationship between share price increases and a

strengthening exchange rate. In addition, the negative lag informs us that the share price change precedes the exchange rate change. The correlations for the surrounding lags (i.e. lags –2 and –4) are actually positive and do not indicate any negative relationship. There is no consistency or justification for this result and it is also considered spurious

The result for Murray and Roberts is interesting as a positive cross-correlation and positive lag has some theoretical basis for a construction company with an export-orientation. A positive cross-correlation with a positive lag was also found for Murray and Roberts (also for the Rand/Euro exchange rate) for weekly return intervals. The similar findings for weekly and monthly return intervals indicate that Murray and Roberts appears to have behaved like a Rand Hedge (against the Euro) although there appears to be a delayed response in the stock price of several months.

6 CONCLUSIONS

Exchange rate fluctuations are believed to affect the value of construction companies with foreign sales and/or operations for various economic reasons. The purpose of this research has been to determine the relationship between both the Rand/US Dollar and Rand/Euro exchange rates, and the value of construction companies listed on the Johannesburg Stock Exchange.

Previous research in this field has focussed on operating exposure investigations and more recently on causal link investigations. The operating exposure research indicated that companies, which are exposed to exchange risk, tend to have a high proportion of foreign sales and also have operations in other countries. South African construction companies have similar characteristics. Other determinants of exchange rate exposure included the characteristics of the industry and company-specific variables such as hedging activities.

The causal link research highlighted some of the weaknesses of using a regression model to calculate the relationship between exchange rates and share prices. Regression modelling involves the implicit assumption of a causal link. Correlation analysis was used in this research report instead to investigate the direction and strength of the linear relationship between exchange rates and share prices. The correlation analysis steps included ARIMA modelling (to remove the relationship between the variables and time) followed by the calculation of the cross-correlation coefficients. Positive and negative lags of the response variable (share price or index value) were investigated and daily, weekly and monthly data were used.

The main finding of the research is that the Murray and Roberts share price is significantly positively correlated with the Rand/Euro exchange rate for weekly and monthly data (delayed response in the share price to exchange rate change). A weakening of the exchange rate in this case corresponds with an increase in the share price, several periods (weeks or months) later. Several other significant correlations were discovered for other companies and

construction indices although no further deductions could be made as the direction of the cross-correlation coefficients and direction of the lags were unstable for the return intervals (daily, weekly and monthly) considered. The underlying economic theory did also not support these results and they were considered to be spurious.

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