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IMPACT OF RESOURCE PRICES AND THE EXCHANGE RATE ON RESOURCE COMPANY SHARE PRICES LISTED ON JSE LTD

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A Research Report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration

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ABSTRACT

It is believed that resource companies which derive their earnings from selling resources predominantly in foreign currency should be significantly exposed to both the exchange rate and the resource price. The aim of this research was to better explain the exposures facing resource companies listed on the Johannesburg Stock Exchange by including both the exchange rate as well as the underlying resource prices. The study made use of ARIMA modelling to remove each data series relationship with time and correlation analysis to establish if a significant relationship existed. The study was conducted over a three, five and ten year period. The findings indicate that the resource index had a significant relationship with the exchange rate over all three periods and that 53% of resource companies had a significant relationship over the 5 and 10 year periods, this dropped to 35% over the 3 year period. As for the underlying resource prices, it was found that the resource index had a significant relationship over all 3 periods and that 82% of the firms in the study had a significant relationship over the 5 and 10 periods and 76% over the 3 year period.

THE DECLARATION

I, Norman Bengt Klasen, 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.

Signature

Norman Bengt Klasen

December, 2006

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1 INTRODUCTION

In an investigation of resource companies listed on the JSE, it was found that neither the index nor the individual companies behaved as a Rand hedge (Lumley, 2002). It was believed that other factors appeared to have masked the exchange rate influence and that commodity prices might have played a major role. Following on from this, this research aims to better explain the exposures of resource companies. This is done in order to make transparent, choices available to managers and investors. The theories pertaining to exposure, hedging and efficient market hypothesis are presented. These are accompanied by relevant examples thereof. ARIMA models will be developed to isolate unexpected changes in share prices, exchange rates and resource prices. These are then analyzed to see if any relationship exists.

1.1 Purpose and Rationale of the Study

The volatility of exchange rates and resource prices play a prolific role in the effective operational strategies of companies. As stated by Bartov and Bodnar (1994:1755), “the exchange rate is one of the most important prices in the economy. It is the price of one country’s currency in terms of another, and as such, it converts prices denominated in one currency into prices denominated in another currency. Changes in exchange rates should therefore have a significant effect on the performance of firms involved in international activities.” In addition Jorion (1990) finds that exchange rates are typically four times as volatile as interest rates and ten times as volatile as inflation. As can be seen in the table on the next page, resource prices are typically also very volatile.

Table 1.1: Commodity Prices - Annualised 22-Day Historical Volatility

	2003	2004	2005	2006H1
Platinum	17%	21%	12%	21%
Gold	16%	14%	12%	25%
Aluminum	14%	19%	20%	29%
Oil (Brent)	37%	34%	36%	30%
Tin	17%	28%	27%	31%
Copper	17%	27%	22%	33%
Nickel	27%	43%	30%	33%
Lead	23%	41%	28%	39%
Zinc	17%	24%	26%	44%
Silver	20%	36%	23%	46%
Palladium	41%	35%	24%	47%

Source: Steinitz (2006)

Thus the objective of this study is to develop a model that includes exchange rates as well as resource prices. This model will be used to determine if this better explains the exposures of individual resource companies as well as the resource index.

These findings will enable managers as well as investors to gain a better understanding of the exposures that face resource firms. It will assist managers of firms to better recognize what exposure risks they face and thus to develop effective hedging strategies. Investors and fund managers will also be able to make more informed investment decisions.

1.2 Problem Statement

This research seeks to investigate the relationship between the resource prices and the exchange rate to the share price of resource companies.

1.3 Scope

This study will be limited to an investigation of resource companies listed under the JSE top 20 Resource sector. The study will also only include resources that are tracked on I-Net Bridge. The latest financial / resource information will be used to determine which resources the individual companies produce and only these resources will be included when testing for relationships for the individual firms.

The study will be conducted over three time periods: a three, five and ten-year period ranging from 1996 to 2006.

It is not within the scope of this study to investigate any other extraneous factors on the market value of a company.

2 LITERATURE REVIEW

2.1 Defining exposure

Bodnar and Marston (2000) define exposure as a measure of the sensitivity of a firm's cash flows to changes in exchange rates. At a more enriched level Miller (1998) specifies that it is the extent to which external environmental contingencies affect a company's performance.

Miller (1998) and McCarthy and Ispriani (2004) differentiate between three types of exchange rate exposures:

- *Translation exposure*, also known as accounting exposure, refers to the impact exchange rate changes can have on a firm's consolidated accounts.

- *Transaction exposure* refers to the gains or losses made from invoice or purchase order date, to date of payment.

- *Operating exposure* refers to the change in a company's future cash flow due to changes such as a company's competitive situation, cost structure, pricing and market share.

Operating exposure is by far the most important and influential of the three. Shapiro (1977:37) states that, "the sector of the economy a firm operates in (export, import competing, or purely domestic) and the source of its inputs (imports, domestic traded or non-trade goods) are far more important in delineating a firm's true economic exposure than is any accounting definition". Furthermore, Shapiro (2004) argues that a purely domestic firm producing solely

for the domestic market and using only domestic sources of input could face operating exposure as changes in the value of domestic currency would affect its competitive position.

Tufano (1998) studied to what extent North American Gold Mining firms were effected by the gold price. Within this exposure, his findings revealed that the average mining stock moves 2 percent for each 1 percent change in the gold price, but that exposures varied considerably across time and across firms. He also found that hedging could significantly reduce a firm's exposure.

Fang, Ho, Lin, and Poon (2004) investigated Australian Gold mining firms and also found that a firm's stock returns are sensitive to the Gold price, with their gold betas consistently being greater than one. Their findings also indicated that hedging reduces a firm's exposure and thus increases shareholder wealth.

Oxelheim and Wihlborg (1987, p178) state that, "as long as exchange rate changes are viewed independently of the changes of other price variables (such as interest rates, inflation rates and relative prices), it is impossible to develop a consistent principle for measuring and managing the exchange rate risk of a corporation." They thus argue that a more comprehensive model should be used that includes all the various forms of exposure.

2.2 Hedging

Traditional hedging techniques include currency options, futures, currency swaps, etc. and these can be used to hedge against translation and transaction exposure. However, for a company to protect itself against operating exposure, this would involve a far more strategic approach. According to Shapiro (2004) considerations include changing the input mix ("shop the world"), shifting production among plants, plant relocation, or structuring the firm's liabilities in

such a way that the reduction in asset earnings is matched by corresponding decrease in cost of servicing liabilities.

This strategic thinking is used very successfully by large motor vehicle manufactures such as Daimler Chrysler who source their inputs worldwide and are also able to shift production between their worldwide plants.

The investment community also make extensive use of hedging to protect their investments against currency depreciation and inflation. It is thought that resource companies, with their sales being mostly related to the dollar, are an excellent currency hedge. However, conclusive findings of this phenomenon are currently varied as seen in examples mentioned at the end of this chapter.

Jorion (1991) states that modern portfolio theory implies that investors don't reward firms for engaging in hedging activities as these can be hedged away by the investors themselves. On the other hand Jorion also mentions that Ross (1976) suggested that investors may be willing to pay a premium for hedging activities as long as these lead to a reduction of business risk factors.

2.3 Measuring Exposure

Measuring exposure makes use of various types of analysis in order to draw specific conclusions. The majority of previous studies made use of regression analysis to examine the sensitivity of the share prices to exchange rates. Examples include: Jorion (1990), Bartov and Bodnar (1994), He and Ng (1998), Di Iorio and Faff (1999), and Lumley (2002). Fox (1997) defines regression analysis as a method for determining the association between a dependent variable and one or more independent variables.

Researchers also make use of multiple regression models to identify the effects of various other independent variables on the share price. Fang, Ho, Lin and Poon (2004) make use of a multi-factor regression model in their examination of Australian gold mining firms' exposure to the gold price and exchange rates. Prasad and Rajan (2003) also make use of a multi-factor regression model (the findings of which are presented in section 2.5: *Examples of Prior Research*) to examine the exposure of firms to the exchange rate and interest rates.

Various authors; Granger and Newbold (1974), Newbold and Davies (1978) and Nelson and Kang (1984), however, warn against the use of regression analysis when analysing economic data. They argue that economic data is generally non-stationary i.e. exhibits a trend and is correlated to its own past: a phenomenon, which is called autocorrelation. This causes the results of regression analysis to show a high degree of fit (R^2), where in fact no such relationship exists. The normal approach to alleviate this problem, which was used in many of the above-mentioned studies, is the inclusion of an additional dependent variable or taking the first differences of the variables involved. According to Granger and Newbold (1974) and Nelson and Kang (1984) this only partially alleviates the problem and spurious results can still occur.

To overcome this problem, Granger and Newbold (1974) suggest building a single series model for each data variable using the Box and Jenkins ARIMA methodology and then searching for relationships between the series by relating the residuals from these single models. According to Granger and Newbold (1974:111) the rational for such an approach is as follows:

> In building a forecasting model, the time series analyst regards the series to be forecast as containing two components. The first is that part of the series, which can be explained in terms of its own past behaviour and the second is the residual part [A_t in eq. (4)], which cannot. Thus, in order to explain this residual element one must

look for other sources of information-related time series, or perhaps considerations of a non-quantitative nature. Hence, in building regression equations, the quantity to be explained is variation in A_t - not variation in the original series.

Examples where this methodology was utilised include Atindehou and Gueyie (2001) in their study of Canadian chartered banks' stock returns and exchange rate risk. They used ARIMA models to extract unexpected interest and exchange rates from the series of interest rate and exchange rate movements and then went on to use these in a regression equation. On a more local level Van Druten (2005), in his research of the relationship between exchange rate and construction company share prices, also makes use of ARIMA modelling to isolate the residuals (the residuals are what is left over from the data once its dependence on time has been removed). He then analyses the residuals using correlation analysis to establish if they are related.

Bartov and Bodnar (1994) note that financial information is generally released to the public with a time lag, wherein it takes longer for exchange rate changes to have an effect on companies' cash flows. In their study Bartov and Bodnar (1994) found that lagged, and not contemporaneous changes, in the dollar, affected stock returns of U.S. firms. On the other hand, He and Ng (1998), in their study of Japanese multinationals did not find a lagged reaction whereas Donnelly and Sheehy (1996) in a study of UK based firms found a weak lagged relationship.

In summary the method proposed by Granger and Newbold (1974) is the preferred method for analyzing exposure as it overcomes the problems of spurious results that are associated with normal regression analysis.

2.4 Efficient Market Hypothesis

In order for the resource price and the exchange rate to justifiably be reflected in the share price one would have to assume the presence of an efficient market.

The Efficient Market Hypothesis was developed by Fama in the 1960's. The Efficient Market Hypothesis states that at any given time, security prices are appropriate and fully reflect all available information. He coined the *random walk* theory, which asserts that price movements will not follow any patterns or trends and that past price movements cannot be used to predict future price movements.

At a more specific level it is helpful to study Fama's (1965:34) original definition of this idea. He stated that:

> An "efficient" market is defined as a market where there are large numbers of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants. In an efficient market, competition among the many intelligent participants leads to a situation where, at any point in time, actual prices of individual securities already reflect the effects of information based both on events that have already occurred and on events which, as of now, the market expects to take place in the future. In other words, in an efficient market at any point in time the actual price of a security will be a good estimate of its intrinsic value.

In 1969 Fama differentiated three levels of market efficiency, which he again expanded in a later publication in 1991. These three levels are: *Test for return predictability*, *Event studies* and *Test for private Information*.

Test for return predictability deals with the predictability of stock returns from past returns and other variables like dividend yields, interest rates, exchange rates, commodity prices, and seasonality in returns.

Event studies concerns the adjustment of stock prices to public information about investment decisions such as divided changes, changes in capital structure and corporate-control transactions.

Test for private information tests if private insider information leads to abnormal returns.

While the core of Fama's theories originated from as early as the 1960's he continues to be a prolific theorist in this area and in fact more recent research confirms that the Efficient Market Hypothesis still has validity today.

Malkil (2003), in an effort to challenge Fama's theories evaluated several supposed market-beating strategies. These include momentum in short run stock prices, under reaction to new information, the bandwagon effect, the January effect and long run return reversals. He found that they are not actually dependable from period to period and that the non-random effects are very small in relation to the transaction cost. He thus concluded that there does not appear to be any arbitrage opportunities that would enable investors to make excess risk-adjusted returns.

In South Africa, Thompson and Ward (1995) found that there is mixed evidence as to whether the JSE operates as an efficient market in the weak and semi-strong forms. He concluded that there is not sufficient abnormal price behaviour to make it worthwhile for the average investor to seek opportunities for superior returns. He thus argued that on this basis the JSE is regarded as being operationally efficient.

Based on the above, it is assumed for the purpose of this research that the JSE can be considered an **operationally efficient market** and that exchange rates and resource prices are both public knowledge and these are thus reflected in the share price.

2.5 Examples of prior research

2.5.1 International Studies

Shapiro (1975), in his study of multinational corporations established that exposure to exchange rates is far greater than depicted by the traditional accounting definition of gains and losses of net current assets.

Shapiro (1977), in another study two years later observed that “a firms actual exchange risk can only be determined by examining the impact of variations in exchange rates on variations in the firm’s worldwide consolidated earnings.” He also stated that, “the sector of the economy a firm operates in (export, import competing, or purely domestic) and the source of its inputs (imports, domestic traded or nontrade goods) are far more important in delineating a firm’s true economic exposure than is any accounting definition.”

Jorion (1990) identified significant exchange rate exposure for U.S. multinationals. The exposure was found to be positively and reliably correlated with the degree of foreign involvement.

Jorion (1991) the very next year tested whether the currency exposure of U.S. firms was priced in a way that conformed to Ross’s (1976) Arbitrage Pricing Theory. He, however, found that there was little evidence that U.S. investors require compensation for bearing exchange risk. The premium

attached to pure foreign exchange rate exposure was found to be in the order of only 0.2 percent per annum, which is both economically and statistically insignificant.

Bartov and Bodnar (1994), in a study of U.S. firms, in which they employed regression analysis, found that contemporaneous changes in the dollar have little power in explaining abnormal stock returns for their sample firms. Within this study they also concluded that lagged changes in the dollar are a significant variable in explaining current abnormal returns suggesting that mispricing does occur.

Donnelly and Sheehy's (1996) UK-based study indicated a contemporaneous relationship between the exchange rate and the value of the portfolio of export intensive firms chosen for the study.

He and K.Ng (1998) found that 25-percent of the 171 Japanese multinationals investigated, had a significant positive exchange rate exposure. Contrary to U.S. studies, there was little evidence that lagged exchange rate changes had any explanatory power. They also found that companies that hedge are less exposed to exchange rate risks.

Tufano (1998), in a study of North American gold mining firms found that the firms are exposed to the gold price but that this exposure can be managed to some extent by hedging, the size of the firm and financial leverage of the firm.

Miller and Reuer (1998) make use of a multiple regression model to test for U.S. manufacturing firms exposure to various different currencies. Their findings are that 13 to 17 percent of U.S. manufacturing firms are exposed to foreign exchange rate movements.

Di Iorio and Faff's (1999) findings indicated that Australian firms manage their short-term exposure (transaction exposure), but do not manage to successfully hedge their long term (operating exposure). They also find that daily data provides more insightful results.

Bodnar and Marston (2000) measured exchange rate exposure from a sample of 103 U.S. firms that participated in the 1998 Wharton/CIBC Survey of Risk Management by U.S. Non-Financial Firms. They analysed a company's foreign exchange reserves and found that on the whole companies' exposure was fairly low due to effective hedging.

Glaum *et al* (2000) used regression analysis to examine economic exposure of German corporations to changes in the DM/US dollar exchange rate. The study was conducted over four periods and found that German corporations are exposed to the exchange rate but that the exposure changes over time.

Dominguez and Tesar (2001) in their study of a relatively broad sample of countries over a 19-year period produced results that indicate a high degree of exchange rate exposure at both the firm and industry level across eight countries using multiple exchange rates.

Prasad and Rajan (2003) examined German, Japanese, British, and American firms for exchange rate and interest rate exposure to equity markets. Through the use of multiple regression analysis, they found evidence of exchange rate sensitivity in each of the four markets.

McCarthy and Ispriani (2004), in their case study of the Foster Group Limited found that their products are price sensitive and a change in exchange rate will thus influence the company's cash flows. They suggested that the

company manage its operating exposure by differentiating its products, and shifting production amongst its plants.

Fang, Ho, Lin and Poon (2004) examined the determinants of gold beta using Australian gold mining firms from 1995 to 2000. They reported that the values of gold beta are consistently greater than one, implying the sensitive nature of the firms' stock returns to gold price changes. This also suggests that investors holding gold mining stock would receive higher percentage increases in stock returns from a percentage increase in gold price returns, as opposed to investors holding gold bullion.

2.5.2 South African Studies

Jordaan (1986) investigated exposure of 90 South African firms to the U.S. Dollar exchange rate. His randomly selected sample included thirty mining shares, thirty financial shares and thirty industrial shares. He found that only seventeen shares were significantly exposed but that subsequent analyses placed doubt on the stability of the sign of these correlations. He thus concluded that no significant relationship exists.

Moodley (2001) in a South African case study of five exporter firms and five local market firms used regression analysis to test for operating exposure. The findings were that only one of the exporter firms and none of the local market firms demonstrated any significant relationship between its value and the exchange rates.

Lumley (2002) used a simple regression model to test for South African resource companies' exposure to the U.S. Dollar. His findings were that the Resource index and the Mining index were partial Rand hedges, but that none of the underlying shares behaved as a Rand hedge.

Van Druten (2005) made use of ARIMA modelling and correlation analysis in his study of South African construction companies' exposure to the Dollar and Euro exchange rates. His findings were that only one of the six construction firms analysed showed a significant but lagged exposure to the Rand/Euro exchange rate.

3 HYPOTHESES

Hypothesis 1 will ascertain if there is a relationship between the exchange rate and the share price of individual resource companies.

H_o: There is no relationship between the exchange rate and the share price of individual resource companies.

H_a: There is a relationship between the exchange rate and the share price of individual resource companies.

Hypothesis 2 will ascertain if there is a relationship between the underlying resources prices (the resources the company produces) and the share price of individual resource companies.

H_o: There is no relationship between the underlying resources prices and the share price of the individual resource companies.

H_a: There is a relationship between the underlying resources prices and the share price of the individual resource companies.

Hypothesis 3 will ascertain if there is a relationship between exchange rate and the resource index.

H_o: There is no relationship between the exchange rate and the resource index.

H_a: There is a relationship between the exchange rate and the resource index.

Hypothesis 4 will ascertain if there is a relationship between any of the resource prices tracked by I-Net Bridge and the resource-index.

H_o: There is no relationship between the resource prices and the resource index.

H_a: There is a relationship between the resource prices and the resource index.

4 METHODOLOGY

This study made use of the methodology suggested by Granger and Newbold (1974), which was introduced in the *Literature Review* above. Granger and Newbold (1974) and others' research found that using regression analysis on economic data can lead to spurious results. Granger and Newbold thus recommend building a single series model for each data variable using the Box and Jenkins ARIMA methodology and then searching for relationships between the series by relating the residuals from these single models.

This research will thus make use of the ARIMA methodology to isolate the residuals of the individual data series (i.e. share prices, exchange rates and resource prices). The residuals will then be studied using correlation analysis to investigate if any relationships exist.

4.1 Limitations

In terms of limitations, no dividend payments were included in the study. Furthermore, this study did not investigate any other extraneous factors on the market value of a company.

4.2 Population

The population included all companies listed on the JSE Top 20 Resource Index.

4.3 Sample size and selection

According to Robertson and Van Rensburg (2001), South African studies that investigate share returns often suffer from problems of thinly traded shares. To

overcome this problem this research only included companies that are in the Resource Top 20 Index. These are generally larger companies with regular trading activity.

As some of the resource data tracked by I-Net Bridge is not available on a daily basis this study made use of weekly data.

The sample included the following companies that are listed under the JSE Top 20 Resource Sector and the JSE Top 20 Resource Index itself.

Table 4.1: List of companies included in JSE Top 20 Resource Sector

Code	Description
J210	FTSE/JSE:AFR RES 20
ARI	AFRICAN RAINBOW
AGL	ANGLO
ANG	ANGLOGOLD ASHANTI
AMS	ANGLOPLAT
BPL	BARPLATS
BIL	BHPBILL
DRD	DRDGOLD
GFI	GFIELDS
HAR	HARMONY
IMP	IMPALA PLATINUM
KMB	KUMBA
MRF	MERAFE
MTX	METOREX
MVL	MVELA
NHM	NORTHAM PLATINUM
SOL	SASOL
SCN	SCHARRIG MINING
SXR	SXR
TSX	TRANS HEX
WAR	W AREAS

Data sourced from I-Net Bridge (August 2006)

For ARIMA modeling to provide reliable results, it requires a sample size of at least 50 data points, therefore, new companies were included from the first day of listing, as long the required number of data points were available.

As most resources are priced and sold in US Dollar terms it is logical to conclude that companies are also most exposed to changes in the US Dollar. Therefore only the US Dollar Rand (USDZAR) exchange rate was used in this study.

Only resources that were identified as being produced by the sample companies and that are tracked by I-Net Bridge were used in the study.

Table 4.2: List of resources used in the study:

Code	Description
Precious Metals	
GOLDPM	GOLD LONDON – PM FIX
PALL	PALLADIUM PM – FIX
PLATPM	PLATINUM PM - FIX ($OZ)
RHOD	RHODIUM PRICE ($/OZ)
SILVER	SILVER SPOT - H-L-C (US$/OZ)
Industrial Metals	
ALUM	ALUMINIUM CASH LME ($/TON) - FIX
COBLT3	COBALT PRICE - 99.3% $/LB
COPP	COPPER CASH LME ($/TON) - FIX
FCRS	FERRO-CHROME SPOT PRICE CIF ($/LB CR)
IRID	IRIDIUM PRICE ($/OZ)
LEAD	LEAD CASH LME ($/TON) - FIX
MANG	MANGANESE ORE PRICE 48/50% CIF ($/MTU MN)
NICK	NICKEL CASH LME ($/TON) - FIX
RUTH	RUTHENIUM PRICE ($/OZ)
SCRC	STEEL COLD ROLLED COIL PRICE FOB ($/TONNE)
VANS	VANADIUM SPOT PRICE 98% CIF ($/LB V2O5)
ZINC	ZINC CASH LME ($/TON) - FIX
ZIRCF$	ZIRCON BULK FOUNDRY GRADE PRICE (US$/TONNE)
Energy Products	
COAL59	COAL : FOB EX ARA NAR 5900 ($/TONNE) - SACR
ELLSWT	OIL : LIGHT LOUISIANA SWEET/ST.JAMES
URAN	URANIUM OXIDE PRICE CIF ($/LB U3O8)

Data sourced from I-Net Bridge (August 2006)

Where more then one price per resource was available the following logic was used:

- The resource denominated in U.S. Dollars was chosen.

- If both an AM and PM price was available the PM price was chosen.

- Future prices are ignored; only daily spot prices were chosen.

- Where there were a number of similar resources where the prices were highly correlated, only one of the resource prices was chosen:

  Example: The correlation between steel cold rolled coil price and steel hot rolled coil price is 98.1% thus the cold rolled steel price was chosen for the study.

- Where the resource is priced in different units such as tons, kilograms and ounces the most popular unit was chosen.

  As an example, the following gold prices are tracked by I-Net Bridge:

Table 4.3: Example of Gold Prices tracked by I-Net Bridge

Code	Description
GLFX	$ GOLD AM/PM FIXES (HI/LO)
GOLDF	GOLD - COMEX NEAR FUTURE
GOLDF1	GOLD - COMEX NEAR FUTURE +1
GOLDAM	GOLD LONDON - AM FIX
GOLDPM	GOLD LONDON - PM FIX
GOLR	GOLD PRICE (RANDS)
GPRK	GOLD PRICE (RANDS/KILOGRAM)
DGLDS	GOLD SPOT - H-L-C (US$/OZ)
GOLDCX	GOLD SPOT 100 OZ – COMEX

Data sourced from I-Net Bridge (Ausgust 2006)

From the above list the Gold London – PM Fix was chosen for the study.

The study will only investigate relationships between the sample companies and the resources which the individual companies produce. This information was

obtained by analyzing the company's latest financial / resource information. In some cases a proxy was used instead of the actual resource produced by the firm. For instance due to the fact that I-Net Bridge does not track the price of Iron ore the cold rolled steel coil price was used as a proxy. Another example of this is where instead of the actual resources produced by Sasol the Light Louisiana Oil price was used (The Oil price was found to be highly correlated to the Petrol, Diesel and Paraffin prices). The exchange rate will always be included and for the index the relationship with all of the above resources will be investigated. Following is a matrix showing which relationships will be investigated:

Table 4.4:	Company / Resource Matrix																						
		USDZAR	GOLD	PALLADIUM	PLATINUM	RHODIUM	SILVER	ALUMINIUM	COBALT	COPPER	CHROME	IRIDIUM	LEAD	MANGANESE	NICKEL	RUTHENIUM	STEEL C-R	VANADIUM	ZINC	ZIRCON	COAL	OIL	URANIUM
FTSE/JSE:AFR RES 20	J210	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AFRICAN RAINBOW	ARI	X	X		X				X	X	X			X	X		X		X				
ANGLO	AGL	X	X	X	X	X	X	X		X			X	X	X		X	X	X	X	X		
ANGLOGOLD ASHANTI	ANG	X	X							X													X
ANGLOPLAT	AMS	X	X	X	X	X				X					X								
BARPLATS	BPL	X	X	X	X	X						X				X							
BHPBILL	BIL	X	X				X	X		X			X	X	X		X		X		X	X	X
DRDGOLD	DRD	X	X																				
GFIELDS	GFI	X	X																				
HARMONY	HAR	X	X																				
IMPALA PLATINUM	IMP	X		X	X	X									X								
KUMBA	KMB	X											X	X			X		X	X	X		
MERAFE	MRF	X									X						X						
METOREX	MTX	X	X						X	X											X		
MVELA	MVL	X	X		X																		
NORTHAM PLATINUM	NHM	X	X	X	X	X									X								
SASOL	SOL	X																			X	X	
SCHARRIG MINING	SCN	X																			X		
SXR	SXR	X																					X
TRANS HEX	TSX	X																					
W AREAS	WAR	X	X																				

4.4 Research Period

The study will be conducted over the following three time periods:

- Over 10 Years from 1st August 1996 to 31st July 2006,
- Over 5 Years from 1st August 2001 to 31st July 2006,
- Over 3 Years from 1st August 2003 to 31st July 2006.

A period of 10 years was chosen to establish if any long-run relationships exists. This will be followed by shorter periods of 5 and 3 years to investigate shorter-term relationships.

4.5 Instrument Design

No forms or other instruments were needed to conduct this research.

4.6 Data Collection

- The following weekly data was downloaded from I-Net Bridge:
    - Share prices and Resource Index as indicated in table 4. 1 above,
    - Resource prices as indicated in table 4.2 above,
    - The USDZAR exchange rate.

- The companies' latest financial / production information was downloaded from the respective company websites and was used to construct Table 4.4 above.

- The data was visually checked for completeness. Data downloaded from I-Net Bridge is assumed to be correct.

4.7 Data Analysis

When applying the methodology suggested by Granger and Newbold (1974) the first step is to isolate the residuals of the individual data series using the Box and Jenkins ARIMA methodology. The following steps will thus be taken for all the share data, the index, the exchange rate and the individual resource data series.

Below is a brief description of the Box and Jenkins ARIMA methodology from Makridakis *et al* (1998, 1978) and Pankratz (1983).

1. Data Preparation

The first step is to analyse the data plot to ascertain if the data is stationary in its variance. (Example: Data is non-stationary in its variance if the variance increases over time). If the data is not stationary the most common approach to achieving a stationary variance is to use a logarithmic or power transformation of the data.

Next the data has to be stationary in its mean. This means that there is no growth or decline in the data. This can be established by looking at a plot of the data or more specifically by examining the auto and partial autocorrelations. In general the autocorrelations for non-stationary data will be relatively large and positive. The partial autocorrelations will typically show a large spike close to lag 1 for non-stationary data. There are several ways to

make the data stationary in its mean. The more popular one, which was proposed by Box-Jenkins, and which will be used for this study, is the method of differentiating the data. Another method is to use trend removal to make the data stationary.

2. Potential Model Selection

Once the data is stationary in its mean and variance, the auto correlations and partial auto correlations can be examined to identify potential models. The following table can be used as a guide to identify suitable model parameters.

Table 4.5: Guide to identifying suitable model parameters

Process	ACF	PACF
AR(1)	Exponential decay	Spike at lag 1, then cuts off to zero.
AR(p)	Exponential decay or damped sine-wave	Spikes at lags 1 to p, then cuts off to zero.
MA(1)	Spike at lag 1 then cuts off to zero.	Exponential decay.
MA(q)	Spikes at lags 1 to q, then cuts off to zero.	Exponential decay or damped sine wave.

Table from Makrodakis *et al* (1998)

3. Model Testing

At this stage the model is run several times using several different parameters that were estimated previously. The models are diagnosed in several different ways and the model with the best overall fit is chosen.

Diagnostics include:

- Checking Auto and Partial Autocorrelations of residuals.

- Portmanteau testing of residuals.

- Using P-values to test the significance of the parameters.

- Selecting the model with the smallest Akaike's Information Criterion or AIC.

- Residuals left over after fitting the model should be white noise.

Once the steps in the ARIMA methodology have been completed the residuals of the share / index data series will be checked against the residual data series of the exchange rate and the resource prices (As per matrix in Table 4.4). The results of the correlation analysis will then be analysed for any significant relationships using large sample confidence limits at a 95% confidence level.

Excel will be used as a spreadsheet and for the correlation analysis. NCSS will be used to isolate the residuals using the ARIMA modelling technique described above.

5 RESULTS

To reiterate, ARIMA modelling was used to isolate the residuals of the individual data series (i.e. share prices, exchange rates and resource prices). The residuals are then analysed using correlation analysis to determine if a relationship exists.

In the next two tables it is important to note that in some cases there were only very small differences between the different ARIMA models. If this occurred the model with the smallest AIC (Akaike's Information Criterion) value was chosen. In a few instances the model did not result in a perfect fitting Portmanteau test. When this occurred the model producing the best fit and smallest AIC value was selected. It should be noted that as per Makridakis et al (1998) close fitting models produce very similar results and should thus have a negligible effect on the study.

The table below shows the Index and Share data chosen for the study and the corresponding ARIMA model selected to isolate the residuals.

Table 5.1: Index and Share data and ARIMA model used to isolate residuals

Code	Description	Data Period Covered		No. of Data Points	ARIMA Model Chosen
		From	To		
J210	FTSE/JSE:AFR RES 20	1998/03/01	2006/06/25	435	(0,1,1)
ARI	AFRICAN RAINBOW	2000/07/09	2006/06/25	312	(5,1,0)
AGL	ANGLO	1996/07/07	2006/06/25	521	(0,1,0)
ANG	ANGLOGOLD ASHANTI	1996/07/07	2006/06/25	521	(0,1,2)
AMS	ANGLOPLAT	1996/07/07	2006/06/25	521	(0,1,2)
BPL	BARPLATS	1996/07/07	2006/06/25	521	(1,1,0)
BIL	BHPBILL	1997/08/03	2006/06/25	465	(0,1,1)
DRD	DRDGOLD	1996/07/07	2006/06/25	521	(5,1,0)
GFI	ELAND	1996/07/07	2006/06/25	521	(8,1,0)
HAR	GFIELDS	1996/07/07	2006/06/25	521	(5,1,5)
IMP	HARMONY	1996/07/07	2006/06/25	521	(0,1,8)
KMB	KUMBA	2001/12/02	2006/06/25	239	(0,1,0)
MRF	MERAFE	1999/12/26	2006/06/25	340	(4,1,0)
MTX	METOREX	1999/12/12	2006/06/25	342	(9,1,0)
MVL	MVELA	1998/11/15	2006/06/25	398	(0,1,1)

NHM	NORTHAM PLATINUM	1996/07/07	2006/06/25	521	(0,1,0)
SOL	SASOL	1996/07/07	2006/06/25	521	(0,1,2)
SCN	SCHARRIG MINING	1996/07/07	2006/06/25	521	(5,1,0)
SXR	SXR	2005/12/25	2006/06/25	27	Excluded
TSX	TRANS HEX	1996/07/07	2006/06/25	521	Excluded
WAR	W AREAS	1996/07/07	2006/06/25	521	(0,1,2)

As can be seen the SXR and Trans Hex shares were excluded from the study. The SXR share was just recently listed and thus did not have enough data points to conduct the study. Trans Hex primarily mine Diamonds and I-Net Bridge does not track the Diamond price, they were therefore also excluded.

In addition it can be noted that not the full 10 years of data was available for all companies and the index. Thus the dates for which they were available is specified in conjunction with the number of data points.

The following table lists the exchange rate, resources and the corresponding ARIMA models chosen.

Table 5.2 Exchange Rate and Resource data and ARIMA model used to isolate residuals

Code	Description	Data Period Covered		No. of Data Points	ARIMA Model Chosen
		From	To		
USDZAR	USD / Rand Ex Rate	1996/07/07	2006/06/25	521	(1,1,0)
GOLDPM	GOLD	1996/07/07	2006/06/25	521	(9,1,0)
PALL	PALLADIUM	1996/07/07	2006/06/25	521	(3,1,0)
PLATPM	PLATINUM	1996/07/07	2006/06/25	521	(0,1,0)
RHOD	RHODIUM	1996/07/07	2006/06/25	521	(5,1,0)
SILVER	SILVER	1996/07/07	2006/06/25	521	(9,1,0)
ALUM	ALUMINUM	1996/07/07	2006/06/25	521	(4,1,0)
COBLT3	COBALT	1996/07/07	2006/06/25	521	(4,1,0)
COPP	COPPER	1996/07/07	2006/06/25	521	(9,1,0)
FCRS	CHROME	1996/07/07	2006/06/25	521	(0,1,0)
IRID	IRIDIUM	1996/07/07	2006/06/25	521	(3,1,0)
LEAD	LEAD	1996/07/07	2006/06/25	521	(0,1,0)
MANG	MANGANESE	1996/07/07	2006/06/25	521	(0,1,0)
NICK	NICKEL	1996/07/07	2006/06/25	521	(0,1,0)
RUTH	RUTHENIUM	1996/07/07	2006/06/25	521	(2,1,0)
SCRC	STEEL C-R	1996/07/07	2006/06/25	521	(5,1,0)

VANS	VANADIUM	1996/07/07	2006/06/25	521	(5,1,0)
ZINC	ZINC	1996/07/07	2006/06/25	521	(0,1,3)
ZIRCF$	ZIRCON	1996/07/07	2006/06/25	521	(0,1,0)
COAL59	COAL	1996/07/07	2006/06/25	521	(0,1,4)
ELLSWT	OIL	1996/07/07	2006/06/25	521	(7,1,0)
URAN	URANIUM	1996/07/07	2006/06/25	521	(5,1,0)

The next collection of tables and research results are presented in order to demonstrate the Cross Correlation Matrix between the residuals of the Index / Share prices and the residuals of the exchange rate and resource prices.

Each table is headed with the share / index code and name. The tables include the periods studied and shows the three different time periods analysed.

The following formula: 1.96/squareroot (n) is used to determine the large sample confidence limit at a 95% significance level. It is presented in the upper quadrant of each table in order to identify the criteria by which results were considered significant or not. The 99% level is also presented in order to indicate those instances that were comparatively more significant. The formula for this level is: 2.576/squareroot (n) were (n) is used to represent the number of data points. A grey shading is then used over those results that were found to have a significant correlation. Were these instances occur the Ho Hypotheses as discussed in chapter 3 of this research paper can be rejected. Fields that are significant at a 99% level are additionally formatted in bold fonts.

Table 5.3 Cross Correlation Matrix between the residuals of the Resource 20 Index price and the residuals of the exchange rate and resource prices.

J210							Large sample confidence Limits for 8 Years @ 95%=+/-		**0.094**		@ 99%=+/-		**0.124**							
FTSE/JSE:AFR RES 20							Large sample confidence Limits for 5 Years @ 95%=+/-		**0.122**		@ 99%=+/-		**0.16**							
From: 29/03/98		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-		**0.157**		@ 99%=+/-		**0.207**							
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
8	**0.271**	**0.329**	**0.148**	**0.219**	0.058	**0.342**	**0.278**	0.050	**0.411**	-0.009	-0.026	**0.197**	-0.002	**0.300**	-0.033	-0.059	0.013	**0.314**	-0.070	-0.014	**0.216**	0.007
5	**0.320**	**0.344**	**0.277**	**0.227**	0.087	**0.357**	**0.293**	0.063	**0.435**	-0.016	-0.034	**0.200**	0.007	**0.321**	-0.007	-0.074	0.014	**0.331**	-0.110	-0.014	**0.230**	-0.016
3	**0.212**	**0.428**	**0.406**	**0.319**	0.108	**0.437**	**0.370**	0.075	**0.512**	0.014	-0.023	**0.248**	0.007	**0.348**	-0.004	-0.074	0.023	**0.382**	-0.126	-0.035	**0.284**	-0.025

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.4 Cross Correlation Matrix between the residuals of the African Rainbow share price and the residuals of the exchange rate and resource prices.

ARI							Large sample confidence Limits for 6 Years @ 95%=+/-						**0.112**		@ 99%=+/-		**0.147**			
AFRICAN RAINBOW							Large sample confidence Limits for 5 Years @ 95%=+/-						**0.122**		@ 99%=+/-		**0.16**			
From: 06/08/00		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-						**0.157**		@ 99%=+/-		**0.207**			
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
6	**0.160**	**0.274**		**0.171**				0.067	**0.224**	0.012			0.048	**0.147**		-0.092		**0.196**				
5	**0.168**	**0.298**		**0.185**				0.085	**0.228**	-0.036			0.053	**0.163**		-0.100		**0.211**				
3	0.172	**0.396**		**0.299**				0.089	**0.282**	0.012			0.071	0.164		-0.143		**0.271**				

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.5 Cross Correlation Matrix between the residuals of the Anglo share price and the residuals of the exchange rate and resource prices.

AGL											Large sample confidence Limits for 10 Years @ 95%=+/-			**0.086**		@ 99%=+/-		**0.113**		
ANGLO											Large sample confidence Limits for 5 Years @ 95%=+/-			**0.122**		@ 99%=+/-		**0.16**		
From: 07/07/96			To: 25/06/06								Large sample confidence Limits for 3 Years @ 95%=+/-			**0.157**		@ 99%=+/-		**0.207**		
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	**0.267**	**0.213**	0.097	**0.144**	0.039	**0.263**	**0.203**		**0.314**			**0.160**	-0.056	**0.228**		-0.041	-0.009	**0.231**	-0.059	-0.017		
5	**0.347**	**0.223**	**0.209**	0.154	0.062	**0.297**	**0.229**		**0.371**			**0.175**	-0.056	**0.263**		-0.059	-0.008	**0.272**	-0.121	-0.017		
3	**0.269**	**0.332**	**0.378**	**0.268**	0.092	**0.410**	**0.321**		**0.480**			**0.238**	-0.077	**0.305**		-0.051	-0.006	**0.338**	-0.151	-0.030		

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.6 Cross Correlation Matrix between the residuals of the Anglogold Ashanti share price and the residuals of the exchange rate and resource prices.

ANG									Large sample confidence Limits for 10 Years @ 95%=+/-				**0.086**		@ 99%=+/-		**0.113**				
ANGLOGOLD ASHANTI									Large sample confidence Limits for 5 Years @ 95%=+/-				**0.122**		@ 99%=+/-		**0.16**				
From: 07/07/96		To: 25/06/06							Large sample confidence Limits for 3 Years @ 95%=+/-				**0.157**		@ 99%=+/-		**0.207**				
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	**0.122**	**0.460**							**0.187**													0.015
5	0.150	**0.445**							**0.236**													-0.028
3	0.082	**0.488**							**0.333**													-0.033

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.7 Cross Correlation Matrix between the residuals of the Angloplat share price and the residuals of the exchange rate and resource prices.

AMS							Large sample confidence Limits for 10 Years @ 95%=+/-					**0.086**		@ 99%=+/-		**0.113**				
ANGLOPLAT							Large sample confidence Limits for 5 Years @ 95%=+/-					**0.122**		@ 99%=+/-		**0.16**				
From: 07/07/96		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-					**0.157**		@ 99%=+/-		**0.207**				
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	**0.197**	**0.216**	**0.180**	**0.266**	0.104				**0.201**					**0.200**								
5	**0.264**	**0.244**	**0.344**	**0.278**	**0.168**				**0.248**					**0.197**								
3	**0.267**	**0.287**	**0.364**	**0.250**	0.204				**0.269**					0.175								

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.8 Cross Correlation Matrix between the residuals of the Barplats share price and the residuals of the exchange rate and resource prices.

BPL							Large sample confidence Limits for 10 Years @ 95%=+/-				**0.086**		@ 99%=+/-		**0.113**					
BARPLATS							Large sample confidence Limits for 5 Years @ 95%=+/-				**0.122**		@ 99%=+/-		**0.16**					
From: 07/07/96		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-				**0.157**		@ 99%=+/-		**0.207**					
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	0.059	0.081	**0.115**	**0.123**	0.027						0.059				0.063							
5	0.065	0.100	0.118	0.086	0.078						0.111				0.055							
3	-0.037	0.109	0.095	0.066	0.080						0.165				0.009							

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.9 Cross Correlation Matrix between the residuals of the BHP Billiton share price and the residuals of the exchange rate and resource prices.

BIL												Large sample confidence Limits for 9 Years @ 95%=+/-		**0.091**		@ 99%=+/-		**0.12**		
BHPBILL												Large sample confidence Limits for 5 Years @ 95%=+/-		**0.122**		@ 99%=+/-		**0.16**		
From: 31/08/97		To: 25/06/06										Large sample confidence Limits for 3 Years @ 95%=+/-		**0.157**		@ 99%=+/-		**0.207**		
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
9	**0.220**	**0.232**				**0.278**	**0.270**		**0.410**	-0.003		**0.206**	0.081	**0.315**		-0.076		**0.310**		-0.018	**0.267**	-0.039
5	**0.272**	**0.260**				**0.317**	**0.306**		**0.452**	0.004		**0.221**	0.095	**0.362**		-0.101		**0.349**		-0.028	**0.333**	-0.071
3	0.128	**0.368**				**0.400**	**0.365**		**0.513**	0.047		**0.257**	0.110	**0.392**		-0.129		**0.383**		-0.040	**0.394**	-0.093

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.10 Cross Correlation Matrix between the residuals of the DRDGOLD's share price and the residuals of the exchange rate and resource prices.

DRD							Large sample confidence Limits for 10 Years @ 95%=+/-					**0.086**		@ 99%=+/-		**0.113**					
DRDGOLD							Large sample confidence Limits for 5 Years @ 95%=+/-					**0.122**		@ 99%=+/-		**0.16**					
From: 07/07/96		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-					**0.157**		@ 99%=+/-		**0.207**					
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	-0.023	**0.325**																				
5	-0.019	**0.307**																				
3	0.030	**0.309**																				

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.11 Cross Correlation Matrix between the residuals of the Goldfields share price and the residuals of the exchange rate and resource prices.

GFI							Large sample confidence Limits for 10 Years @ 95%=+/-							**0.086**		@ 99%=+/-		**0.113**			
GFIELDS							Large sample confidence Limits for 5 Years @ 95%=+/-							**0.122**		@ 99%=+/-		**0.16**			
From: 07/07/96		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-							**0.157**		@ 99%=+/-		**0.207**			
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	0.084	**0.441**																				
5	0.110	**0.423**																				
3	0.112	**0.527**																				

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.12 Cross Correlation Matrix between the residuals of the Harmony share price and the residuals of the exchange rate and resource prices.

HAR							Large sample confidence Limits for 10 Years @ 95%=+/-					**0.086**		@ 99%=+/-		**0.113**					
HARMONY							Large sample confidence Limits for 5 Years @ 95%=+/-					**0.122**		@ 99%=+/-		**0.16**					
From: 07/07/96		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-					**0.157**		@ 99%=+/-		**0.207**					
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	**0.120**	**0.372**																				
5	0.157	**0.339**																				
3	0.188	**0.414**																				

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.13 Cross Correlation Matrix between the residuals of the Kumba share price and the residuals of the exchange rate and resource prices.

KMB							Large sample confidence Limits for 4 Years @ 95%=+/-					**0.128**		@ 99%=+/-		**0.168**				
KUMBA							Large sample confidence Limits for 4 Years @ 95%=+/-					**0.128**		@ 99%=+/-		**0.16**				
From: 30/12/01			To: 25/06/06				Large sample confidence Limits for 3 Years @ 95%=+/-					**0.157**		@ 99%=+/-		**0.207**				
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
4	0.057											0.081	0.103			-0.015		0.054	-0.061	0.030		
4	0.057											0.081	0.103			-0.015		0.054	-0.061	0.030		
3	0.039											0.096	0.116			-0.008		0.050	-0.063	0.022		

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.14 Cross Correlation Matrix between the residuals of the MERAFE's share price and the residuals of the exchange rate and resource prices.

MRF							Large sample confidence Limits for 6 Years @ 95%=+/-				**0.107**		@ 99%=+/-		**0.141**					
MERAFE							Large sample confidence Limits for 5 Years @ 95%=+/-				**0.122**		@ 99%=+/-		**0.16**					
From: 23/01/00		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-				**0.157**		@ 99%=+/-		**0.207**					
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
6	**0.154**									-0.031												
5	0.157									-0.037												
3	0.161									0.000												

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.15 Cross Correlation Matrix between the residuals of the Metorex share price and the residuals of the exchange rate and resource prices.

MTX								Large sample confidence Limits for 6 Years @ 95%=+/-					**0.107**		@ 99%=+/-	**0.14**				
METOREX								Large sample confidence Limits for 5 Years @ 95%=+/-					**0.122**		@ 99%=+/-	**0.16**				
From: 09/01/00			To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-					**0.157**		@ 99%=+/-	**0.207**				
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
6	0.048	**0.225**						0.001	**0.334**											-0.051		
5	0.069	**0.257**						0.015	**0.374**											-0.047		
3	0.101	**0.338**						-0.013	**0.438**											-0.076		

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.16 Cross Correlation Matrix between the residuals of the MVELA's share price and the residuals of the exchange rate and resource prices.

MVL							Large sample confidence Limits for 8 Years @ 95%=+/-							**0.099**		@ 99%=+/-		**0.13**			
MVELA							Large sample confidence Limits for 5 Years @ 95%=+/-							**0.122**		@ 99%=+/-		**0.16**			
From: 13/12/98		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-							**0.157**		@ 99%=+/-		**0.207**			
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
8	0.008	**0.259**		**0.211**																		
5	-0.002	**0.316**		**0.292**																		
3	0.027	**0.383**		**0.307**																		

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.17 Cross Correlation Matrix between the residuals of the Northam Platinum's share price and the residuals of the exchange rate and resource prices.

NHM							Large sample confidence Limits for 10 Years @ 95%=+/-					**0.086**		@ 99%=+/-		**0.113**				
NORTHAM PLATINUM							Large sample confidence Limits for 5 Years @ 95%=+/-					**0.122**		@ 99%=+/-		**0.16**				
From: 07/07/96		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-					**0.157**		@ 99%=+/-		**0.207**				
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	**0.178**	**0.261**	**0.230**	**0.273**	0.091									**0.155**								
5	**0.220**	**0.278**	**0.298**	**0.261**	**0.169**									**0.166**								
3	0.180	**0.352**	**0.350**	**0.297**	0.199									0.154								

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.18 Cross Correlation Matrix between the residuals of the Sasol's share price and the residuals of the exchange rate and resource prices.

SOL							Large sample confidence Limits for 10 Years @ 95%=+/-					**0.086**		@ 99%=+/-		**0.113**					
SASOL							Large sample confidence Limits for 5 Years @ 95%=+/-					**0.122**		@ 99%=+/-		**0.16**					
From: 07/07/96		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-					**0.157**		@ 99%=+/-		**0.207**					
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	**0.118**																			0.018	**0.254**	
5	0.145																			0.024	**0.277**	
3	0.052																			0.008	**0.314**	

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.19 Cross Correlation Matrix between the residuals of the Scharrig Mining's share price and the residuals of the exchange rate and resource prices.

SCN							Large sample confidence Limits for 10 Years @ 95%=+/-						**0.086**		@ 99%=+/-		**0.113**				
SCHARRIG MINING							Large sample confidence Limits for 5 Years @ 95%=+/-						**0.122**		@ 99%=+/-		**0.16**				
From: 07/07/96		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-						**0.157**		@ 99%=+/-		**0.207**				
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	0.032																			0.021		
5	0.048																			0.027		
3	0.087																			0.016		

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.20 Cross Correlation Matrix between the residuals of the Western Areas share price and the residuals of the exchange rate and resource prices.

WAR							Large sample confidence Limits for 10 Years @ 95%=+/-						**0.086**		@ 99%=+/-		**0.113**				
W AREAS							Large sample confidence Limits for 5 Years @ 95%=+/-						**0.122**		@ 99%=+/-		**0.16**				
From: 07/07/96		To: 25/06/06					Large sample confidence Limits for 3 Years @ 95%=+/-						**0.157**		@ 99%=+/-		**0.207**				
Years +/-	**USDZAR**	**GOLD**	**PALLADIUM**	**PLATINUM**	**RHODIUM**	**SILVER**	**ALUMINIUM**	**COBALT**	**COPPER**	**CHROME**	**IRIDIUM**	**LEAD**	**MANGANESE**	**NICKEL**	**RUTHENIUM**	**STEEL C-R**	**VANADIUM**	**ZINC**	**ZIRCON**	**COAL**	**OIL**	**URANIUM**
10	-0.043	**0.213**																				
5	-0.059	**0.173**																				
3	-0.061	0.089																				

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

Table 5.21 Summary of Cross Correlation Matrix's between the residuals of the index / share price and the residuals of the exchange rate and resource prices.

	Years +/-	USDZAR	GOLD	PALLADIUM	PLATINUM	RHODIUM	SILVER	ALUMINIUM	COBALT	COPPER	CHROME	IRIDIUM	LEAD	MANGANESE	NICKEL	RUTHENIUM	STEEL C-R	VANADIUM	ZINC	ZIRCON	COAL	OIL	URANIUM	No. of Resources Exposed to.
J210 FTSE/JSE:AFR RES 20	**8**	**0.27**	**0.33**	**0.15**	**0.22**		**0.34**	**0.28**		**0.41**			**0.20**		**0.30**				**0.31**			**0.22**		**10**
	5	**0.32**	**0.34**	**0.28**	**0.23**		**0.36**	**0.29**		**0.44**			**0.20**		**0.32**				**0.33**			**0.23**		**10**
	3	**0.21**	**0.43**	**0.41**	**0.32**		**0.44**	**0.37**		**0.51**			**0.25**		**0.35**				**0.38**			**0.28**		**10**
ARI AFRICAN RAINBOW	**6**	**0.16**	**0.27**		**0.17**					**0.22**					**0.15**				**0.20**					**5**
	5	**0.17**	**0.30**		**0.18**					**0.23**					**0.16**				**0.21**					**5**
	3	0.17	**0.40**		**0.30**					**0.28**					0.16				**0.27**					**5**
AGL ANGLO	**10**	**0.27**	**0.21**	0.10	**0.14**		**0.26**	**0.20**		**0.31**			**0.16**		**0.23**				**0.23**					**9**
	5	**0.35**	**0.22**	**0.21**	0.15		**0.30**	**0.23**		**0.37**			**0.17**		**0.26**				**0.27**					**9**
	3	**0.27**	**0.33**	**0.38**	**0.27**		**0.41**	**0.32**		**0.48**			**0.24**		**0.30**				**0.34**					**9**
ANG ANGLOGOLD ASHANTI	**10**	**0.12**	**0.46**							**0.19**														**2**
	5	0.15	**0.45**							**0.24**														**2**
	3		**0.49**							**0.33**														**2**
AMS ANGLOPLAT	**10**	**0.20**	**0.22**	**0.18**	**0.27**	0.10				**0.20**					**0.20**									**6**
	5	**0.26**	**0.24**	**0.34**	**0.28**	**0.17**				**0.25**					**0.20**									**6**
	3	**0.27**	**0.29**	**0.36**	**0.25**	0.20				**0.27**					0.18									**6**
BPL BARPLATS	**10**			**0.12**	**0.12**																			**2**
	5																							
	3											0.17												**1**
BIL BHPBILL	**9**	**0.22**					**0.28**	**0.27**		**0.41**			**0.21**		**0.31**				**0.31**			**0.27**		**7**
	5	**0.27**					**0.32**	**0.31**		**0.45**			**0.22**		**0.36**				**0.35**			**0.33**		**7**
	3						**0.40**	**0.37**		**0.51**			**0.26**		**0.39**				**0.38**			**0.39**		**7**
DRD DRDGOLD	**10**		**0.32**																					**1**
	5		**0.31**																					**1**
	3		**0.31**																					**1**
GFI GFIELDS	**10**		**0.44**																					**1**
	5		**0.42**																					**1**
	3		**0.53**																					**1**

- Continued on next page

	Years +/-	USDZAR	GOLD	PALLADIUM	PLATINUM	RHODIUM	SILVER	ALUMINIUM	COBALT	COPPER	CHROME	IRIDIUM	LEAD	MANGANESE	NICKEL	RUTHENIUM	STEEL C-R	VANADIUM	ZINC	ZIRCON	COAL	OIL	URANIUM	No. of Resources Exposed to.
HAR	**10**	**0.12**	**0.37**																					**1**
HARMONY	**5**	0.16	**0.34**																					**1**
	3	0.19	**0.41**																					**1**
KMB	**4**																							
KUMBA	**4**																							
	3																							
MRF	**6**	**0.15**																						
MERAFE	**5**	0.16																						
	3	0.16																						
MTX	**6**		**0.22**							**0.33**														**2**
METOREX	**5**		**0.26**							**0.37**														**2**
	3		**0.34**							**0.44**														**2**
MVL	**8**		**0.26**		**0.21**																			**2**
MVELA	**5**		**0.32**		**0.29**																			**2**
	3		**0.38**		**0.31**																			**2**
NHM	**10**	**0.18**	**0.26**	**0.23**	**0.27**	0.09									**0.16**									**5**
NORTHAM PLATINUM	**5**	**0.22**	**0.28**	**0.30**	**0.26**	**0.17**									**0.17**									**5**
	3	0.18	**0.35**	**0.35**	**0.30**	0.20																		**4**
SOL	**10**	**0.12**																				**0.25**		**1**
SASOL	**5**	0.14																				**0.28**		**1**
	3																					**0.31**		**1**
SCN	**10**																							
SCHARRIG MINING	**5**																							
	3																							
WAR	**10**		**0.21**																					**1**
W AREAS	**5**		**0.17**																					**1**
	3																							
Summary	**10**	**9**	**11**	**4**	**6**	**2**	**2**	**2**	**0**	**6**	**0**	**0**	**2**	**0**	**5**	**0**	**0**	**0**	**3**	**0**	**0**	**2**	**0**	**14**
(No. of Companies	**5**	**9**	**11**	**3**	**5**	**2**	**2**	**2**	**0**	**6**	**0**	**0**	**2**	**0**	**5**	**0**	**0**	**0**	**3**	**0**	**0**	**2**	**0**	**13**
Exposed to each Item)	**3**	**6**	**10**	**3**	**5**	**2**	**2**	**2**	**0**	**6**	**0**	**1**	**2**	**0**	**4**	**0**	**0**	**0**	**3**	**0**	**0**	**2**	**0**	**13**

All shaded fields represent significant relationships at a 95% significance level and the Null Hypothesis can thus be rejected for these fields. (Fields that are shaded and were the text is bolded represent a 99% significance level)

6 INTERPRETATION OF RESULTS

When interpreting the results the following should be remembered. Companies in the research sector generally sell resources that are priced in USD dollar terms. One would thus expect that a relationship with the currency exists. Similarly one would also expect there to be a relationship with the price of resources that the companies produce. Both these relationships can be mitigated by the companies by engaging in hedging activities and by operational measures. But these measures generally only provide partial cover and are short term in nature. With the assumption that markets are efficient these factors should be incorporated in the share price immediately. In summary one would expect a positive cross correlation between the index / share price and the exchange rate and resource prices. A negative correlation would not make sense as it would mean that the exchange rate or resource price would be affected by the share price. This would not be in line with what theory suggests.

It must be also borne in mind that some resources prices are correlated to each other such as Gold and Silver. As an example a company that produces both Gold and Silver but derives most of its turnover / profits from Gold could show up with a misleadingly high correlation to Silver (Due to the Silver price being correlated with Gold price). This will not however influence the overall study as the aim of this study is not to investigate what effect individual resources have on a company / index but rather whether the resource prices overall have an effect on the company / index. Therefore if at least one of the resources that a company produces shows a significant correlation this research will conclude that the company is affected by resource prices. Information related to correlations which individual resources have with a company / index are displayed and will be discussed but must be treated with caution.

6.1 Comment on Index

As can be seen from table 5.3 in the previous section the Resource 20 index has a significantly relationship over all three time periods with the exchange rate and ten of the resources which were included in the study. This is in line with what theory and intuition would suggest but differs from research conducted by Lumley (2002) who did not find a significant relationship between the resource index and the exchange rate. This could be ascribed to the different methodology and time periods used in this research. Of interest are also which resources do not have a significant influence on the index. One example would be coal which is mined on a large scale and also is used as an input for Sasol but yet does not have a significant affect on the index or any other shares in the study.

6.2 Comment on Shares

6.2.1 African Rainbow

The African Rainbow share price shows a strong significant relationship (At a 99% significance level) with the exchange rate over the 6 and 5 year periods over which this study was conducted. For the 3 year period the relationship only holds true at a 95% significance level. For the resources five out of the nine resources that the company produces showed significant results over all three time periods, with all resources besides nickel over the 3 year time period being significant at a 99% level. It is assumed that the resources were no significant result was found either form a very small part of African Rainbows activities or that the company had effective hedging policies in place.

6.2.2 Anglo

As can be seen the Anglo share price shows a strong correlation with the exchange rate over all three periods. When comparing the table below with the correlations in table 5.5 in the previous chapter, one can see that the strong correlations of Gold, Platinum, Palladium, Copper and Aluminium tie in with a high percentage of Anglo's turnover. Nickel, Lead, Silver and Zinc also show a strong correlation although they only account for a fairly small percentage of Anglo's turnover. Rhodium, Manganese, Vanadium, and Zircon show non significant correlations which, as expected, tie into small percentages of turnover. Surprisingly however Coal and Steel C-R don't show a significant correlation although they make up a large percentage of Anglo Americans turnover.

Table 6.1: Percentages of Anglo turnover

Anglo Resources (included in the Study)	% of turnover
Platinum (and Related)	11%
Gold	8%
Coal	10%
Copper	8%
Nickel, Niobium, Mineral Sands	2%
Zinc	1%
Ferrous Metals	12%
Samancor Group (Manganese)	2%
Tongaat-Hulett (Sugar & Aluminum)	4%

Source: Adapted from Anglo Annual Report 2005

6.2.3 Anglogold Ashanti

As can be seen from Table 5.6 in the previous section Anglogold Ashanti shows a long term relationship with the exchange rate with the 5 and 10 year results showing a positive relationship. In the short term however no relationship with the exchange rate seems to exist. As expected from a predominantly gold producing firm a strong relationship with the gold price exists. The Copper price also shows

a significant relationship whereas the Uranium price does not seem to have an effect on the Anglogold Ashanti share price.

6.2.4 Angloplat

As can be seen in table 5.7 of the previous section the Angloplat share price shows a significant relationship with the exchange rate over all three periods. As expected, Angloplat's also has a strong significant relationship with the platinum price. Additionally all the other resources it produces are also significantly correlated.

6.2.5 Barplats

In contrast Barplats which produces almost the identical spectrum of resources as Angloplat's shows no significant relationship with the exchange rate. In addition Platinum, its main resource, only shows a significant relationship over the 10 year period. The only other significant relationship are with Palladium over the 10 year period and Iridium over the 3 year period.

6.2.6 BHP Billiton

As can be seen in table 5.9 of the previous section BHP Billiton has a significant relationship with the exchange rate over the 5 and 10 year periods but not in the short term. When placing the results form the correlation table 5.9 along side BHP Billiton's Production Summary (Which was only available in units) one can see that for the Oil, Aluminium, Copper, Lead, Zinc, Gold, Silver and Nickel all show a significant relationships as expected. Likewise Chrome shows no relationship which also is as expected. Uranium, Steel C-R, Manganese and Coal however don't show a significant relationship although the production numbers are fairly high (At least in unit terms).

Table 6.2: BHP Billiton Production Summary joined with correlation table 5.9

BHP Production Summary		Correlation table 5.9			
RESOURCES	**JUNE 2006**	**Resources**	**Years**		
			9	**5**	**3**
PETROLEUM					
Crude oil & condensate ('000 bbl)	45,873	Oil	**0.267**	**0.333**	**0.394**
Natural gas (bcf)	360				
LPG ('000 tonnes)	814				
Ethane ('000 tonnes)	106				
Total Petroleum Products (million boe)	116				
ALUMINIUM					
Alumina ('000 tonnes)	4,187				
Aluminium ('000 tonnes)	1,362	Aluminum	**0.270**	**0.306**	**0.365**
BASE METALS					
Copper ('000 tonnes)	1,268	Copper	**0.410**	**0.452**	**0.513**
Lead (tonnes)	266,321	Lead	**0.206**	**0.221**	**0.257**
Zinc (tonnes)	109,058	Zinc	**0.310**	**0.349**	**0.383**
Gold (ounces)	216,622	Gold	**0.232**	**0.260**	**0.368**
Silver ('000 ounces)	46,476	Silver	**0.278**	**0.317**	**0.400**
Uranium oxide concentrate (tonnes)	3,936	Uranium	-0.039	-0.071	-0.093
Molybdenum (tonnes)	2,515				
CARBON STEEL MATERIALS					
Iron ore ('000 tonnes)	97,072	Steel C-R	-0.076	-0.101	-0.129
Metallurgical coal ('000 tonnes)	35,643				
Manganese ore ('000 tonnes)	5,280	Manganese	0.081	0.095	0.110
Manganese alloy ('000 tonnes)	652				
DIAMONDS AND SPECIALTY PRODUCTS					
Diamonds ('000 carats)	2,561				
Fertiliser ('000 tonnes)	861				
ENERGY COAL					
Energy coal ('000 tonnes)	85,756	Coal	-0.018	-0.028	-0.040
STAINLESS STEEL MATERIALS					
Nickel ('000 tonnes)	175	Nickel	**0.315**	**0.362**	**0.392**
Ferrochrome ('000 tonnes)	0	Chrome	-0.003	0.004	0.047

Source: Adapted from BHP Billiton Production Report June 2006
(Significant Correlation Results displayed in bold)

6.2.7 DRD Gold

As can be seen from table 5.10 in the previous section DRD Gold has no significant relationship with the exchange rate over all three time periods. But as

expected from a gold producing company it has a significant relationship with the gold price.

6.2.8 Gold Fields

Gold fields is in exactly the same situation as DRD Gold which has no significant relationship with the exchange rate but has a significant relationship with the gold price.

6.2.9 Harmony

As can be seen from table 5.12 in the previous section Harmony has a strong significant relationship (99% significance level) with the exchange rate for the 10 year period. This relationship is only significant at a 95% significance level for the 5 and 3 year periods. Again as expected from a gold producer Harmony has a significant relationship with the gold price.

6.2.10 Kumba

As can be seen from table 5.13 in the previous section Kumba has no significant relationship with the exchange rate. Even more surprising is that it does not have any significant relationships with any of the resources it produces.

6.2.11 Merafe

As can be seen from table 5.14 in the previous section Merafe share price is significantly related to the exchange rate. Astonishingly Merafe being a large chrome producer however shows no relationship between its share price and that of the chrome price for any of the three periods.

6.2.12 Metrorex

As can be seen from table 5.15 in the previous section Metrorex's share price shows no relationship with the exchange rate. It does however shows a significant relationship with the gold and copper price but no relationship with the cobalt and coal price.

6.2.13 Mvela

As can be seen from table 5.16 in the previous section the Mvela share price shows no relationship with the exchange rate. As expected being a gold and platinum producer it shows a significant relationship with the gold and platinum price.

6.2.14 Northam Platinum

As can be seen from the table 5.17 in the previous section the Northam Platinum share price is significantly correlated with the exchange rate over all three time periods. As can be seen from the table below the correlation results for Platinum, Palladium, Rhodium and Nickel (except over 3 years) are to be expected when compared to Northam's Sales figures. The strong correlation to Gold however comes as a surprise as it only makes up one percent of Norham's sales. This result is probably due to the high correlation between the Platinum and Gold price.

Table 6.3: Northam Platinum 2006 Results joined with correlations from table 5.17

NHM 2006 Results			Correlation table 5.17		
Resource	Sales (R000s)	% of Total	Years		
			10	5	3
Platinum	1448160	61%	**0.273**	**0.261**	**0.297**
Palladium	186514	8%	**0.230**	**0.298**	**0.350**
Rhodium	476140	20%	**0.091**	**0.169**	**0.199**
Gold	25242	1%	**0.261**	**0.278**	**0.352**
Nickel	185480	8%	**0.155**	**0.166**	0.154
Other	64790	3%			
Total	2386326				

Source: Adapted from Northam Annual Results June 2006
(Significant Correlation Results displayed in bold)

6.2.15 Sasol

As can be seen in table 5.18 in the previous section the Sasol share price is correlated with the exchange rate for the 5 and 10 year rime periods. Sasol being a large producer of fuel which is highly correlated to the Oil price it comes as no surprise that the study shows a significant relationship with the oil price. Astonishingly there is no significant correlation with the coal price as coal is one of Sasol's major inputs.

6.2.16 Sharrig Mining

As can be seen in table 5.19 in the previous section Sharrig Mining shows no significant relationship with the exchange rate in any of the three periods. Although nearly 100% (Sharrig's Financial Statements, 2005) of Sharrig's turnover comes from coal no significant relationship is found which is counter intuitive.

6.2.17 Western Areas

As can be seen in table 5.20 Western Areas has no significant relationship with the exchange rate over any of the three periods. As expected, for a gold mining firm, it has a significant relationship with the gold resource price over the 5 and 10 year periods but not over the 3 year period.

6.3 Summary of Relationships

The table below shows a summary of all exchange rate and resource price relationships.

Table 6.4: Summary of Relationships

Index and Shares	Years +/-	Relationship with Exchange Rate		Relationship with Resources Prices	
		Significant at 95% Level	Decision	Significant at 95% Level	Decision
FTSE/JSE:AFR RES 20	8	Yes	Reject Ho	Yes	Reject Ho
	5	Yes	Reject Ho	Yes	Reject Ho
	3	Yes	Reject Ho	Yes	Reject Ho
AFRICAN RAINBOW	6	Yes	Reject Ho	Yes	Reject Ho
	5	Yes	Reject Ho	Yes	Reject Ho
	3	Yes	Reject Ho	Yes	Reject Ho
ANGLO	10	Yes	Reject Ho	Yes	Reject Ho
	5	Yes	Reject Ho	Yes	Reject Ho
	3	Yes	Reject Ho	Yes	Reject Ho
ANGLOGOLD ASHANTI	10	Yes	Reject Ho	Yes	Reject Ho
	5	Yes	Reject Ho	Yes	Reject Ho
	3	No	Accept Ho	Yes	Reject Ho
ANGLOPLAT	10	Yes	Reject Ho	Yes	Reject Ho
	5	Yes	Reject Ho	Yes	Reject Ho
	3	Yes	Reject Ho	Yes	Reject Ho
BARPLATS	10	No	Accept Ho	Yes	Reject Ho
	5	No	Accept Ho	No	Accept Ho
	3	No	Accept Ho	Yes	Reject Ho
BHPBILL	9	Yes	Reject Ho	Yes	Reject Ho

	5	Yes	Reject Ho	Yes	Reject Ho
	3	No	Accept Ho	Yes	Reject Ho
DRDGOLD	10	No	Accept Ho	Yes	Reject Ho
	5	No	Accept Ho	Yes	Reject Ho
	3	No	Accept Ho	Yes	Reject Ho
GFIELDS	10	No	Accept Ho	Yes	Reject Ho
	5	No	Accept Ho	Yes	Reject Ho
	3	No	Accept Ho	Yes	Reject Ho
HARMONY	10	Yes	Reject Ho	Yes	Reject Ho
	5	Yes	Reject Ho	Yes	Reject Ho
	3	Yes	Reject Ho	Yes	Reject Ho
KUMBA	4	No	Accept Ho	No	Accept Ho
	4	No	Accept Ho	No	Accept Ho
	3	No	Accept Ho	No	Accept Ho
MERAFE	6	Yes	Reject Ho	No	Accept Ho
	5	Yes	Reject Ho	No	Accept Ho
	3	Yes	Reject Ho	No	Accept Ho
METOREX	6	No	Accept Ho	Yes	Reject Ho
	5	No	Accept Ho	Yes	Reject Ho
	3	No	Accept Ho	Yes	Reject Ho
MVELA	8	No	Accept Ho	Yes	Reject Ho
	5	No	Accept Ho	Yes	Reject Ho
	3	No	Accept Ho	Yes	Reject Ho
NORTHAM	10	Yes	Reject Ho	Yes	Reject Ho
PLATINUM	5	Yes	Reject Ho	Yes	Reject Ho
	3	Yes	Reject Ho	Yes	Reject Ho
SASOL	10	Yes	Reject Ho	Yes	Reject Ho
	5	Yes	Reject Ho	Yes	Reject Ho
	3	No	Accept Ho	Yes	Reject Ho
SCHARRIG	10	No	Accept Ho	No	Accept Ho
MINING	5	No	Accept Ho	No	Accept Ho
	3	No	Accept Ho	No	Accept Ho
W AREAS	10	No	Accept Ho	Yes	Reject Ho
	5	No	Accept Ho	Yes	Reject Ho
	3	No	Accept Ho	No	Accept Ho
Summary	**10**	**9**		**14**	
(No. of Companies	**5**	**9**		**13**	
Exposed)	**3**	**6**		**13**	

The points below will relate the information above back to the research hypothesis.

Hypothesis 1 sought to ascertain if there is a relationship between the exchange rate and the share price of individual resource companies.

As can be seen from the table above, of 17 companies 9 are exposed to the exchange rate over the 5 and 10 year periods and only 6 companies over the 3 year period. One cause of the weakened relationship over the 3 year period could be the fairly stable exchange rate over that time.

The following firms did not show any relationship with the exchange rate over any of the periods: Barplats, Drdgold, Goldfields, Kumba, Metorex, Mvela, Scharrig Mining and Western Areas. All these besides Kumba and Scharrig mining have significant relationships with at least one resource price. This relationship with the resource price could, as suggested by Lumley (2002), have masked the effect on the exchange rate.

Over two of the three periods the majority of firms show a significant relationship with the exchange rate and overall the study shows that the exchange rate does play a role in the majority of resource companies share prices. This goes along with theory in this area which suggests that firms that are predominantly export orientated should be effected by the exchange rate. Thus the Ho Hypothesis can be rejected.

Hypothesis 2 sought to ascertain if there is a relationship between the underlying resources prices (the resources the company produces) and the share price of individual resource companies.

As can be seen from table 6.4, of 17 companies 14 have a significant relationship with at least one resource over the 10 year period and 13 companies have a significant relationship over the 5 and 3 year periods.

Only Kumba, Merafe and Scharrig Mining did not have any relationship with a resource over any of the three time periods. Kumba and Scharrig are both large coal producers and Merafe is a producer of Chrome. Surprisingly none of the 6 companies that were tested for relationships with coal produced significant results. It is likely that the Coal59 price traced by I-Net Bridge proved to be a poor proxy for the mix of coal produced by these firms.

As expected and confirmed in this research, resource companies are significantly affected by changes in the price of the resources they produce and the Ho Hypothesis can thus be rejected.

Hypothesis 3 sought to ascertain if there is a relationship between exchange rate and the resource index.

As can be seen from table 6.4 and table 5.3 in the previous section the resource index has a significant relationship with the exchange rate over all three period. This is as theory would suggest but goes against the findings of Lumbley (2002). It is most likely that the use of a different methodology and time periods might have influenced the result. The findings clearly show that a relationship exists and thus the Ho Hypothesis can be rejected.

Hypothesis 4 sought to ascertain if there is a relationship between any of the resource prices tracked by I-Net Bridge and the resource-index.

As can be seen from table 5.3 in the previous section the resource index has a significant relationship with 10 of the resources in the study over all 3 time periods. This clearly indicates that a relationship exists and the Ho Hypothesis can thus be rejected.

7 CONCLUSION

7.1 Summary

This research aimed to better explain the exposures facing resource companies by including both the exchange rate as well as the underlying resource prices. Theory suggests that resource companies which derive their earnings from selling predominantly in foreign currency should be significantly exposed to both the exchange rate and the resource price.

This study made use of a method proposed by Granger and Newbold (1974), which has since been extensively used in business and economic studies involving time series data. The method uses ARIMA modelling to remove the data's dependency on time for each data series. The residuals are then analysed using correlation analysis to determine if a relationship exists. The study was conducted over a three, five and ten year periods.

The results show that the resource index had a significant relationship with the exchange rate over all three periods and that 53% of resource companies had a significant relationship over the 5 and 10 year periods, this dropped to 35% over the 3 year period. As for the underlying resource prices, it was found that the resource index had a significant relationship over all 3 periods and that 82% of the firms in the study had a significant relationship over the 5 and 10 periods and 76% over the 3 year period. Overall 88% of the firms showed some form of exposure. This study thus concurs with current theory that resource companies are exposed to the exchange rate and the underlying resource price

7.2 Recommendations

Managers of resource companies should be aware of the exposures facing there firms, but must be wary when deciding on appropriate hedging strategies. This research shows that operating exposures decrease in the shorter term. This could be purely coincidental due to the time period chosen, or due to operational and hedging measures already in place during the period studied. Further research in this area would possibly give more clarity. This study does however indicate the need for longer term hedging strategies. These could include structuring expenses to be incurred in foreign currency rather than local and procuring foreign currency loans.

Investors wishing to protect themselves against Rand depreciation need to take note that relatively few firms showed a significant relationship with the exchange rate over the 3 year period. The index on the other hand showed a strong relationship over all 3 periods. It would thus be advisable for investors wishing to protect themselves against currency devaluations to invest in the index and not individual firms. Investors wishing to get exposure to resources can however, with a few exceptions, buy shares in companies that produce these resources. Since, as the study shows, a strong relationship exists between the resource prices and the share price.

7.3 Areas for further research

Oxelheim and Wihlborg (1987) argue that to effectively measure operating exposure of companies, variables cannot be viewed independently of each other. They suggest that a more comprehensive model should be constructed. Further research could thus be conducted which includes other variables such as interest rates, inflation rates, reserves, etc. This would give more complete picture of exposure facing resource companies.

Studies conducted by Bartov and Bodnar (1994) and Donnelly and Sheehy (1996) suggest that financial information is generally released to the public with a time lag and thus lagged and not contemporaneous changes effect a companies stock returns. Further research could thus make use of time lags to explore if this better explains the exposures of resource companies.

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