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THE RELATIONSHIP BETWEEN THE ZAR/USD EXCHANGE RATE AND STOCK MARKET INDICES ON THE JOHANNESBURG STOCK EXCHANGE

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ABSTRACT

Multiple studies have looked at the relationship between exchange rates and the stock market due to the significance of the impact of exchange volatility impact on factors such as company earnings, cost of funds when a company borrows in foreign currencies to fund their operations, and the impact on the trade balance and other macro-economic fundamentals based on the extent to which a country is export/import dominant. Limited research has been done to understand this relationship in the South African economy, looking at the Johannesburg Stock Exchange with a particular focus on sector indices.

This paper empirically investigates the relationship between the exchange rate of the ZAR/USD currency pair and the Johannesburg Stock Exchange (JSE) indices at a global and sector level. The paper seeks to further establish the impact of these relationships on stock value. The investigation explores two things; whether there is a causal relationship between the series, and the extent of the impact of one series one another by applying the Granger Causal testing along with Impulse Response testing using the bivariate Vector Autoregression (VAR) model.

Monthly data was used for the analysis which is done over a 10 year period from January 2006 to December 2015 and the 9 industries used are defined by The Industry Classification Benchmark (ICB) include Oil & Gas, Basic Materials, Industrials, Consumer Goods, Health Care, Consumer Services, Telecommunication, Financials and Technology. Results show a significant relationship between the exchange rate and several indices, the exchange rate was found to Granger-cause the All-Share Index and the Industry Index individually. Relationships in the opposite direction were also confirmed where Basic

Materials Index and Consumer Services index were individually found to Granger-cause exchange rate, the casual relationships were all unidirectional. The shocks of the exchange rate on the All-Share Index and the Industry Index were found to be negative and intense but only lasted for a brief period after which stability in the system was achieved. The impact of both the Basic Materials Index and the Consumer Services Index on the exchange rate was also negative with Consumer Services Index having the more pronounced initial effect. Therefore a relatively narrow fluctuation band of exchange rate volatility needs to be maintained and government policies should not seek to weaken the Rand to make South African exports more attractive to the international market as this negatively impact the value of stocks forming part of the All-Share Index and the Industry Index.

DECLARATION

I, **Mohanoe Mokhitli**, hereby declare that this research report entitled: The Dynamic Relationship Between the ZAR/USD Exchange Rate and Stock Market Indices on the Johannesburg Stock Exchange is my own, unless otherwise as specified in the references and acknowledgments. It is submitted in fulfilment of the requirements for the degree of Master of Business Administration at the University of the Witwatersrand, Johannesburg. It has not been previously submitted for any degree or examination in this or any other university.

_____

Mohanoe Mokhitli

Student Number: **1248605**

Signed at_____

On the _____ day of _____ 2017

DEDICATION

I dedicate this research to my family who have supported me proudly and relentlessly. In addition, to a wonderful soul that has become the centre of my life, who has been to me a heavenly gift, a source of inspiration, a companion in difficult times, a beacon in the dark, the voice of reason when I lose my way, and who I will treasure forever, a close friend, Rina Purshotam. I have been able to depend on all of these special people for unconditional support, encouragement and love throughout my MBA journey.

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1. INTRODUCTION

1.1. Purpose of the study

The purpose of the study is to better understand the relationship between the nominal exchange rate and stock price movements within different sector indices represented on the Johannesburg Stock exchange (JSE) with a specific focus on the ZAR/USD which is the price of the Rand in terms of the dollar. This study considers the case of South Africa as an emerging market economy and how the JSE listed stock prices respond to the rand-dollar exchange rate.

1.2. Context of the study

The South African economy is the second largest in Africa with the leading economy currently being Nigeria, South Africa's Gross Domestic Product (GDP) has grown dramatically since the end of international sanctions in 1996. The reported GDP of South Africa as at the end of 2015 was $323 billion and the country is considered an emerging market economy by the World Bank with a GDP per capita of $5, 902. The largest sectors of the South African economy and fastest growing are the services sector accounting for 66% of the GDP and other significant sectors include industry, agriculture and mining. Primary exported goods come from agriculture and resource sectors with the main trading partners being China, United States, Japan, the European Union and India. The ZAR/USD currency exchange pair is therefore one of the mostly watched in the South African economy while the USD is the most traded currency in the world.

The foreign exchange rate between two currencies is the rate at which one unit of currency will be exchanged for another. It is one of the most significant indicators and determinant of a country's level of economic health. With the increase in capital flows between countries, the relaxation of capital controls, globalization, and the adoption of more flexible exchange rate regimes through floating exchange rates, has been a lot more focus on how exchange rates impact the economy (on a macro level) and capital markets. Phylaktis and Ravazzolo (2005), Zhao (2010) points to the information flow from exchange rates to stock prices which entails changes in the exchange rate will provide important information about international trade fundamentals of the economy. This information is incorporated into the stock market. The changes in the exchange rate affect economic activities both domestically and internationally, and the impact can be extensive. The level of effect or influence extends to the supply and demand of the two currencies, capital flows in and out of the country, inflation and interest rate differentials. A strong currency can result in uncompetitive industries on the international market and the loss of stock value on the stock exchange. Conversely, a currency that is too weak can result in inflation as imports become expensive, the costs for business will increase and they will be less profitable causing a reduction of value on the stock market.

Ng'ambi (2015) investigated the dynamic interrelationship between exchange rate volatility and the aggregated and disaggregated capital flow. He concluded that a strong bi-directional causality of portfolio flows with exchange rate volatility exists. This suggests that fluctuations in the exchange rate can be explained by portfolio flow into South Africa's capital markets. In a free market system, the resulting foreign exchange rate will have an impact on interest rates which in turn will influence the present value of the firm's assets. Exchange rates have integral relationships with macroeconomic factors relating to the

trading activities between two countries and a link can be made between stock prices and foreign exchange rates as outlined above. Furthermore, key factors influencing the exchange rate can be summarized as follows;

1.2.1. Differentials in inflation

High inflation rates lead to a depreciation of a country's currency in relation to the currency of its trading partner(s), according to the economic theory of Purchasing Power Parity (PPP). The exchange rate between one currency and another is in equilibrium when their domestic purchasing powers at that rate of exchange are equivalent. A study done by Deravi, Keivan, Gregorowicz, & Hegji (1995) pointed to a change in price level and inflation in response to a change in exchange rate.

1.2.2. Differentials in interest rates

A significantly high correlation between interest rates and exchange rates is already an established relationship and central banks use interest rates as a mechanism to influence the inflation and exchange rates. A study done by Hacker, Karlsson, & Mansson (2014) shows evidence of a negative relationship between interest rates and exchange rates over a shorter time scale and more positive relationships the longer timescales.

1.2.3. Current account deficits

The current account deficit can be defined as the measure of a country's trade where the value of the goods and services it imports exceeds the value of the goods and services it

exports. Early studies indicated the current account as a key influencer of the exchange rate (Dornbusch & Fischer, 1980).

1.2.4. Public debt

Countries with large current account deficits and debts are less attractive to foreign direct investment and will therefore not attract capital inflows and the country's exchange rate will depreciate. This is due to the fact that a large current account deficit and debt encourages inflation based on the fact that a current account deficit reduces money supply (with other variables remaining unchanged), and the central bank may respond by increasing money supply through an expansionary monetary policy, which will increase inflation.

1.2.5. Political risk and economic performance

Foreign investors require stable economies in which to invest their capital. Countries with good economic growth prospects and low political risk will attract foreign direct investment. Political turmoil and instability will result in a loss of confidence from investors in the transfer of capital to currencies that are relatively more stable. Exchange rate risk therefore is an important consideration in investment decisions.

It is an element that should be priced into the stock volatility measure (beta) to ensure that the exchange rate risk is a component of the fluctuation of the stock price around its mean/average price. The exchange rate can be seen as a price of an asset according to Kutty (2010), stating also that the determination of the value/price of that asset is driven

by expectations about future interest differentials between two countries, current account deficits, external debt, terms of trade and the political situation.

A study by Jorion (1991) puts forward evidence of the relationship between share returns and the value of the dollar differing systematically across different industries, and pointing out that some industries including those that are export driven will have a significantly positive exposure to exchange risk and their stock prices will tend to increase when the dollar falls. Other industries display negative exchange rate exposure which is the reverse case, and the study shows the differences being significant (Jorion, 1991). This study and similar studies are predominantly focused on developed countries with none looking at South Africa and the JSE.

From an investor's perspective, diversification is the holy grail of any investment strategy and is the spreading of investment across different "baskets" in an attempt to mitigate against the risk of an economic shock. One of the areas of diversification is the stock investment by sector, which is further enabled by the spreading of risk/investment across sectors with low correlation to each other. A specific shock in a particular sector, labour unrest in mining for example, will affect all the shares in that sector. A portfolio value is therefore likely to decrease if the investment has been diversified only across different mining stocks (effectively meaning no diversification).

If, however, diversification is done across sectors to include consumer goods, referring to the same example, the combined losses resulting from the mining investment would have been reduced.

The main sectors of the South African economy and as represented on the JSE (with percentages representing each sector's market capitalization) are as follows;

1.2.5.1. Oil and Gas (3%)

1.2.5.2. Basic Materials (26%)

1.2.5.3. Industrials (5%)

1.2.5.4. Consumer Goods (16%)

1.2.5.5. Health Care (3%)

1.2.5.6. Consumer Services (20%)

1.2.5.7. Telecommunications (4%)

1.2.5.8. Financials (20%)

1.2.5.9. Technology (3%)

1.3. Problem statement

The stock market plays a key role in attracting investment and facilitating the overall development of a country. Studies by Serven and Solimano (1991) have pointed out the importance of exchange rate stability on employment, economic growth and investment in a country. Understanding the dynamic relationship between exchange rates and the stock market at a sector level would provide important insights into how and to what extent the South African economic sectors are impacted, and/or influence the exchange rates. This is because both these factors serve as a tool to assess risk from an economic policy and asset management point of view. A relationship between the ZAR/USD exchange rate and stock prices across sectors of the economy, as represented on the JSE, has never been carefully considered in the South African context and understood deeply at an industry or economic

sector index level. Furthermore, understanding the integral relationship between the exchange rate and the stock market will enable a deeper understanding of the dynamic between how both variables affect each other.

1.4. Significance of the study

There are two key areas of significance for this particular area of study and investigation:

1.4.1. Understanding the relationship between exchange rate and stock price movements across sectors would allow investors to further understand and explore the pricing of exchange rate risk in their asset pricing model/s. The exchange rate determines how our goods are priced relative to our trading partners in international markets. A weaker currency will encourage more exports and a stronger currency will make imports less expensive if the exports are invoiced in domestic currency. South Africa is an import dominated economy and labour movements, political parties and some economists are consistently calling for a weaker currency.

1.4.2. A weaker currency has both advantages and disadvantages in relation to our economy. Having a better understanding of the exchange rate impact on financial markets gives us a better view of the losses and gains on the financial markets in the different sectors of our economy, and enables us to better predict the likely impact from currency movements.

Previous research conducted in analyzing the relationship between exchange rates and stock prices has been predominantly conducted in developed economies with limited research done in emerging markets, and Africa in particular to look at this relationship at an industry

level. Alam (2011) considered the USD/ZAR relationship with the JSE stock prices at an All-Share level and concluded that no traces of causality exist between the two variables using the Granger causality test. From the same study it is implied that the Johannesburg stock exchange is informationally efficient and investors cannot exchange rates to forecast stock prices in the market. Kutty (2010) considered exchange rates in Mexico while Abdalla and Murinde (1997) looked at financial markets in India, Korea, Pakistan and the Philippines. Granger, Huang, & Yang (2000) found from South Korea data that stock prices lead exchange rates with negative correlation where an appreciation of a currency would result in decrease in stock prices. Furthermore, the study found that the inclusion of exchange rate variations can improve the predictable portion of the stock price changes in the five Asian markets investigated, which include Hong Kong, Malaysia, Singapore, Thailand and Taiwan (Granger *et al*., 2000).

Many other studies have found evidence of a relationship existing between exchange rates and stock prices, with very few taking a closer look from the perspective of sector indices. Taking into consideration the limited understanding and testing of the relationship between stock prices in terms of sector indices and exchange rate movements, better results would be achieved if the exchange rate relationship was tested against different sectors and not over the whole stock exchange as done by most studies including (Phylaktis and Ravazzolo, 2005; Nieh and Lee, 2002; Ma and Kao, 1990; Kutty, 2010; Kim, 2003; Jorion, 1991; Gavin, 1989; and Abdalla and Murinde, 1997).

1.5. Delimitations of the study

1.5.1. The nominal exchange rate between the rand and the dollar are considered

looking at the USD/ZAR currency pair and not the nominal effective exchange

rate, which is the Rand against a basket of currencies of South Africa's major trading partners weighted on a trade volume basis

1.5.2. Only JSE listed companies and related sector indices are included; sectors included are as per The Industry Classification Benchmark (ICB)

1.5.3. This is strictly an analysis of the bivariate relationship between the USD/ZAR exchange rate and the JSE stock market indices and excludes other macro-economic variables and exogenous effects that bear a relationship to exchange rates including the following;

1.5.3.1. Capital flows into the country

1.5.3.2. Interest rates

1.5.3.3. Inflation

1.5.3.4. Current account deficit

1.5.3.5. Public debt

1.5.3.6. Policy risk and economic performance

1.5.4. The analysis is considered on historical data covering 10 years

1.5.5. Weekends and public holidays are excluded from the analysis

1.5.5.1. JSE closes on these days

1.5.5.2. Foreign exchange however continues

1.5.6. Long term dynamic relationship between stock prices and exchange rates

1.5.7. The indices that are used to represent stock prices include the All-Share (J203), Industrials (J520), Consumer Goods (J530), Health Care (J540),

Consumer Services (J550), Telecommunications (J560), Financials (J580) and Technology (J590), Financials (J580), and Oil and Gas (J500).

1.6. Definition of terms

1.6.1. Globalization

Globalization is “a process of interaction and integration among the people, companies, and government of different nations, a process driven by international trade and investment, aided by information technology. This process has effects on the environment, on culture, on political systems, on economic development and prosperity, and on human physical well-being in societies around the world” (“What is Globalization?” 2015).

1.6.2. Nominal Exchange Rate

The nominal exchange rate E is defined as “the number of units of the domestic currency that can purchase a unit of a given foreign currency” (“What is the nominal and real exchange rate?” 2016). A decrease in this variable is termed nominal appreciation of the currency and an increase is termed nominal depreciation of the currency (“What is the nominal and real exchange rate?” 2016).

1.6.3. Stock/Share Price

A stock price is the price of a single share of a number of saleable stocks of a

company, derivatives or other financial asset (“Share Price”, 2015)

1.7. Assumptions

1.7.1. Foreign exchange movements on weekends and public holidays are not considered and only closing prices on week/working days are included in the analysis

1.7.2. The nominal exchange rate is be used

1.7.3. Daily closing stock prices and exchange rates are used

2. LITERATURE REVIEW

2.1. Introduction

This chapter provides an overview and reviews theoretical and empirical studies conducted on a similar topic of this research, and conclusions reached respectively. In addition, this chapter lays the foundation for this research to establish whether a dynamic relationship exists between exchange rates and the stock market in the South African economy. As outlined earlier in Chapter 1, multiple studies conducted across different economies including both developed and emerging markets have found both a significant relationship between the exchange rate market and the stock market, and a lack thereof. The causal relationship between exchange rate and stock prices has also been inconsistent with some studies, Abdalla and Murinde, (1997) and Granger *et al*. (2000) found causality from exchange rate to stock prices while Nieh and Lee (2001), Kutty (2010) found stock prices causing currency exchange rate changes.

Across all the research, no empirical consensus has been reached and neither has the determination been successfully done; of whether firstly a relationship exists between the two variables, and secondly (in addition) the causal direction, whether exchange rates influence stock market performance or vice versa. The research problem for this study is the establishment of the dynamic relationship between exchange rate and stock price across different sectors represented on JSE listed companies. The sub-problem is whether this relationship, if it exists, has a stock value creation effect or a stock value destroying effect. Literature review outlines previous work done on investigating the relationship between these two quantities and results obtained from the research. A background discussion is put

together which leads to the hypothesis followed by the conclusion to the literature review.

2.2. Background Discussion

2.2.1. Floating Exchange Rate and Risk Pricing

The De Kock Commission was established in South Africa in 1978 to investigate the appropriate monetary system and policy that the government of the day should be following to ensure an optimal combination of economic growth, balance of payments equilibrium and internal economic stability (Odhiambo, 2015). The finding from the Commission included a recommendation to float the exchange rate and allow the market to determine the rate which is applied to foreign trade, capital transfers between countries and current account payments. A managed floating exchange rate was adopted from 1979 to manage capital outflows and the devaluation of the Rand, and in 2000 a fully floating exchange rate system was adopted in South Africa where the market would determine the value of the Rand against other currencies with no regulation from government.

This study uses the Rand which is the world's most traded emerging market currency and 18th most traded currency in the world (based on a triennial survey of the size and structure of the global foreign exchange market undertaken by the Bank for International Settlements (BIS)), while the US dollar is the world's most traded currency. The ZAR/USD is the representative currency pair for this study which looks at exchange rate changes and stock price movements on the Johannesburg stock exchange.

2.2.2. Exchange Risk

With increased globalization, more companies operate in multiple geographies and do business with international companies whether they import or export goods and services. There has also been a relaxation of foreign capital controls and this has resulted in an increase of exchange rate risk under a floating currency exchange rate. Based on a paper by Ma and Kao (1990) and Loudon (1993) several types of risks can be identified and these include transaction exposure, arising from gains or losses from settlement of investment transactions stated in foreign currency terms; economic exposure, which arises from movements in firms' discounted cash flows when exchange rates fluctuate; and operating exposure, which is the sensitivity of the home currency value of the firm to changes in exchange rates. Dumas and Solnik (1995) found that exchange risk, defined as the financial risk of an investment's value changing due to the changes in currency exchange rate, is however priced for the four largest countries including the US, UK, Japan and Germany, with no determination being made for emerging economies in Africa particularly.

2.2.3. Exchange Rate and Stock Price

There is an existing and established relationship between foreign exchange rate movements and the performance of the stock prices on a given stock exchange. Multiple studies including Granger *et al*. (2000) found, from the Asia stock markets, that stock prices generally lead exchanges rates with a negative correlation, entailing that stock prices cause exchange rate and in line with the negative correlation, if stock prices increase then exchange rate would appreciate. Solnik (1987) noted a

weak positive relationship between real stock return differentials and changes in the real exchange rate. Abdalla and Murinde (1997) found exchange rates to be causing stock price changes for Korea, Pakistan and India. In the same study, the finding was not the same for Philippines, where the results showed stock prices causing changes in exchange rates.

Using unit root and co-integration models to determine the appropriate Granger relationship (lead-lag) between stock prices and exchange rates, Granger *et al*. (2000) found that exchange rates led stock prices (using data from South Korea), but noted that, although there is a statistical relationship from the Granger Causality study, there may be underlying fundamental economic relationships that are difficult to interpret, giving the example of a recessionary shock on a country. This causes a stock price decrease and exchange rate depreciation, giving rise to a stock price and exchange rate reaction, where both stock price and exchange markets may not play a role in generating the timing relation.

Zhao (2010) looked at monthly exchange rate and stock price data from China and found no stable long-term equilibrium relationship between real effective exchange rate level and stock price exists. Phylaktis and Ravazzolo (2005) studied the long-run and short-run relationships between stock prices and exchange rates using data from a group of Pacific Basin countries, and found evidence that the stock market and foreign exchange markets are positively related. Nucci and Pozzolo (2001) investigated a relationship between exchange rate fluctuations and the investment decisions of a sample of Italian manufacturing firms, and found that a depreciation of the exchange rate has a positive effect on revenue and a negative effect on cost,

with the extent of the effect dependent on the proportion of foreign sales and level of monopoly power, where fluctuations were stronger for firms with low monopoly power.

This study underlines the fact that, firstly, exchange rates do ultimately impact the company value as represented on financial statements, which would translate into an impact on the stock price levels if the company is listed on the stock exchange. In addition, this is one of the few studies that considers the impact of exchange rates at an industry level. This enables us to make comparisons across industries, providing valuable insights and a deeper understanding of macroeconomics in the context of the relationship between exchange rate market and the stock market.

Nieh and Lee (2002) found no long-run significant relationship between stock prices and exchange rate in the G-7 countries which included Canada, Germany, Italy, Japan, France, UK and US. A more recent study that was done by Kutty (2010) looking at Mexico as an emerging economy examined the relationship between stock prices and exchange rate. Using the Granger causality test the results showed that the stock prices lead exchange rate in the short-run with no long-run relationship that can be established.

A study by Kim (2003) took into account several macroeconomic indicators to investigate the existence of a relationship in the US market, and these indicators included stock price, industrial production, real exchange rate, interest rate and inflation. The finding from this study was that the S&P 500 stock price index was negatively related to the real exchange rate, interest rate and inflation. Alam (2011),

in a study to establish the relationship between USD/ZAR exchange rate and the JSE, found no traces of causality between the variables in both directions.

This relationship between currency exchange market and the stock market has implications for multiple areas at a macroeconomic level, including: changes in the prices of imported goods and services, where an appreciation of the currency will reduce the price of imported goods and services; Currency appreciation increasing the price of goods and services to overseas clients; a strong currency slowing GDP growth due to a reduction in net exports, and the demand for jobs decreasing, leading to an increase in unemployment.

In addition, the causal relationship between the two markets have an implication for the development, sustainability and efficiency of stock markets in emerging economies, in line with the policy shifts towards independently floating exchange rates (Abdalla & Murinde, 1997). Furthermore, Murinde (1996) argues that money that is raised in emerging stock markets allows firms to minimize their reliance on debt financing, and to increase overall efficiency, competitiveness and solvency.

2.2.4. Stock Price Behaviour

The behavior of stock prices in response to economic environmental changes locally and globally tend to differ for domestic firms, multinational firms and the type of economic sector the firm operates in. Abdalla and Murinde (1997) noted that resource sector stocks (gold, other metals, solid fuels, gas and oil industries, etc.) and industrial stocks (building materials, chemicals, banking and finance, etc.)

respond differently to changes in the currency exchange rates. The correlation between currency appreciation and industrial stock performance is positive, whereas the correlation for resource stocks is negative.

Aggarwal (1981) argued that a change in exchange rates could change stock prices of multinational firms directly, and those of domestic firms indirectly. For a multinational firm operating without exchange risk hedging, changes in the exchange rate will have a direct impact on its financials as the value of the foreign operations change owing to the currency denomination. For example, if a UK based firm, listed on the London stock exchange and having operations in South Africa, experiences a depreciation of the UK Pound as a base currency to the Rand, this decrease in the Pound value will impact their financials as they report on the South African operation.

In addition, based on economic theory, where a floating exchange policy exists, the exchange rate appreciation reduces the competitiveness of export markets if the exports are invoiced in domestic currency, while for import markets the exchange rate appreciation would lower input costs and this would have a positive impact on the company financials and therefore the performance of the stock. If a firm has both importing and exporting operations, the impact of the exchange rate can be either positive or negative depending on other factors, such as the volumes of import vs. exports, and the product or service itself. Ma and Kao (1990) noted high exchange rate levels being associated with favourable stock price movements, and this was defined as the financial effect. Ma and Kao (1990) further identified the economic effect, where for an export-dominant country, the currency appreciation

will reduce the competitiveness of exports markets and affect the domestic stock market negatively. The opposite is true where for an import dominated country, the currency appreciation will lower import costs and increase value on the stock market.

2.3. Main Problem

The main objective of the study is to analyze and determine the dynamic relationship between the ZAR/USD currency exchange rate and stock prices represented across their relevant economic sectors as indices on the Johannesburg Stock Exchange (JSE). A selection of indices for this analysis include All-Share (J203), Industrials (J520), Consumer Goods (J530), Health Care (J540), Consumer Services (J550), Telecommunications (J560), Financials (J580) and Technology (J590), Financials (J580), and Oil and Gas (J500).

2.3.1. Research Question

Is there a relationship between the exchange rate of the Rand and the identified industry indices on the JSE?

2.3.2. Hypothesis

There is no causal relationship between exchange rates and stock prices on the JSE at a global level and an industry or economic sector index level. In this case, the Granger causality concept is used which is a statistical concept of causality that is based on prediction. According to Granger causality, if a signal X_1 "Granger-

causes" a signal X_2, then past values of X_1 should contain information that helps predict X_2 above and beyond the information contained in past value of X_2 alone (Seth, 2007).

2.4. Conclusion of the Literature Review

Most studies done previously that looked at the relationship between exchange rate and stock prices where monthly data was used and in some cases weekly data. This study makes use of monthly data to align to previous studies for better comparison of results. Granger *et al*. (2000) noted that the inclusion of exchange rate variations within a day can improve predictability of stock price changes with reference to the Asian markets that he considered for the analysis. In addition, prior studies used an index to represent the performance of all the companies listed on the stock exchange, and these studies therefore fail to capture the nuances present in the way different industry stocks change in relation to exchange rate movements.

Griffin and Stulz (2001) found that both industry and exchange rate shocks are more important for industries that produce internationally traded goods, where the objective of the study was to establish whether the competitive effects of bilateral exchange rate shocks are economically significant for shareholders. Furthermore, a study by Jorion (1991) points to evidence on the relationship between stock returns and the value of the dollar differing systematically across industries. In addition, he found that some, mainly export oriented countries, display a significant positive exposure where stock prices increase when the dollar falls (the other go the opposite direction). There is therefore cross- sectional differences that are significant.

What can be considered based on the Granger *et al*. (2000) position is that these recessionary shocks/unfavourable information is an irregular occurrence and therefore may not be adequately representative when looking at the historical data points. Most studies that were done on the developed US economy examining the relationship between stock returns and exchange rates found a weak relationship, with many studies conducted in emerging markets finding the traditional relationship of exchange rates leading stock prices. It would therefore be prudent to look at the relationship between currency exchange rate and the different economic sector indices in order to understand the relationship.

With the integral understanding of the relationship between exchange rates and the stock market, financial managers will be in a position to manage assets better by pricing in the exchange risk and determining the level of economic integration between trading partners represented in the currency pair. Stock prices generally reflect how the market values the stock and can be considered a net present value of future cash flows of the firm. Stock prices will theoretically react to exchange rate rates. In his paper, Zhao (2010) notes that values of financial assets are determined by the present values of their future cash flows. The improved understanding of the relationship between exchange markets and stock markets will guide governments on their monetary policy and help them to realize the following impacts: interest rates impact on exchange rates; and exchange rates impact on the stock market and ultimately the broader economy.

3. RESEARCH METHODOLOGY

3.1. Introduction

The research methodology section covers the data sources, collection methodology and techniques that will be used to conduct the empirical analysis. The analysis techniques that will be used follow some of the more advanced techniques that were used in the literature reviewed. The main objective is to establish whether there is a relationship between exchange rates and stock price movements across different industries in South Africa for JSE listed companies.

3.2. Data Source

Historical ZAR/USD exchange rates and stock market data on the JSE was sourced from ShareData which has in place an advanced data management system that provides investment and stock market information to individuals and companies. On the JSE the SA Sector groups of all listed stocks/instruments are based on the Industry Classification Benchmark (ICB) which is a system that classifies over 70, 000 companies and 75, 000 securities globally. The data sourced consists of monthly movements of exchange rates and stock market indices spanning a period of 10 years from the January 2006 to December 2015. Monthly data is used for better comparison of results from previous studies and only data from January 2006 was available.

3.3. Data Preparation

The main time series is the monthly closing level of market capitalization-weighted indices on the JSE including All-Share (J203), Industrials (J520), Consumer Goods (J530), Health Care (J540), Consumer Services (J550), Telecommunications (J560), Financials (J580) and Technology (J590) for the period January 2006 to December 2015. The ZAR/USD nominal exchange rates will be in the form of units of foreign currency per US dollar (ZAR/USD), and all the directions of the causality will be explored. The data manipulation and preparation for the analysis was done in SAS®9.3 to ensure the data is suitable and of good quality for the analysis. The SAS software does not support missing values and was cleansed and treated to ensure there are no missing observations between periods. Relevant formats were then applied to the date and series data.

3.4. Series Plots

This study is to explore and understand the dynamic relationship between exchange rates and major JSE indices. Empirical approaches such as the Granger Causality are used with graphical approaches to identify and visualize the causal relationships of a multivariate nature. A bivariate series plot is a graph used to evaluate patterns of data over time. How the different series behaves over time in comparison to each other provides clues into the relationship between variables and whether there are potential interactions and general trends.

3.5. Normality Testing

The normal distribution is a common continuous probability distribution and is based on the central limit theorem, which states that the averages of random variables independently drawn from an independent distribution will converge to the normal when the number of variables is large enough (Mardia, 1974). Normality is critical in statistical methods to be used in the paper to assess the relationship between exchange rates and the JSE All-Share and industry specific indices. When the assumption of normality is violated or not verified, the accurate interpretation of results obtained and inferences made cannot be valid and would be questionable. The probability density of the normal distribution takes the form:

(1) $$f(x|u,\sigma^2) = \frac{1}{\sqrt{2\sigma^{2\pi}}}\ e^{-(x-u)^2/2\sigma\hat{}2}$$

Where:

- μ is the mean of the distribution
- σ is the standard deviation
- σ^2 is the variance

Graphical and numerical methods will be used for establishing normality of the variables. The Graphical method displays the distribution of the random variable by a dot plot and histogram, and compares the distribution to a theoretical one by using plots. The numerical method calculates skewness, kurtosis and applies statistical tests to examine normality. Both methods were employed in the analysis due to the judgement based nature of interpretation of the numerical method.

3.6. Unit Root and Cointegration Testing

Statistical methods that are applied in this paper are based on the assumption that the time series is stationary. A stationary time series is one whose statistical properties including descriptive statistics and autocorrelation are constant over time. Most economic time series are not stationary and if there exists a stationary linear combination of nonstationary random variable, the variables combined are referred to as cointegrated. We need to test for stationarity characteristics of the series and the validity of results obtained. In addition, spurious regression can result where if two variables are trending over time, regressing one variable on another can result in a high R-squared value even if the two variables are totally unrelated.

If the series is not stationary then the standard assumptions for asymptotic analysis will not be valid and hypothesis testing with assumed hypotheses cannot be undertaken. Unit root test is employed to test for stationarity in a series. The hypothesis that will be tested is whether there is a presence of a unit root and the alternative hypothesis is absence of a unit root and therefore stationarity. SAS® allows the user to test for a unit root using a few tests including the Augmented Dickey-Fuller (ADF), Johansen cointegration test and Stock-Watson common trends test (Dickey, Hasza, & Fuller, 1984). The ADF test will be used for this study and stationarity is a necessary precondition for employing Granger causality test. The ADF test will test the hypothesis that a time series y_t is I (1) against the alternative that is I (0), and to test for a unit root using the ADF test, one estimates the following model:

(2) $y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 t + \sum_{i=1}^{n} \alpha_i \Delta y_{t-1} + \mu_t$

If the series has a unit root, $\beta 1 = 0$ and$\sum_{i=1}^{n} \alpha_i \Delta y_{t-1} = 1$. The ADF test is a test of the hypothesis that $\beta 1 = 0$ given n lagged first differences. A series y_t is integrated of order 0 and covariance stationary if it's mean, variance and autocovariance are time independent. A process is integrated of order 1 (I (1)) if it is not stationary but its first difference is stationary where $\Delta y_t = y_t - y_{t-1}$ is I (0). If we have a multivariate time series, SAS® has a procedure to estimate model parameters associated with vector autoregressive moving-average processes with endogenous and exogenous regressors. These models are defined in terms of the orders of the autoregressive or moving-average process or both. The choice of lag length is critical in that if too few lags are specified, there will be remaining autocorrelation and size distortion and too many lag are specified then effectiveness of the test will be compromised.

Ng and Perron (2001) outlined an approach where a maximum lag length is specified and then estimates the ADF model and if the t-statistic for the last lagged first difference is greater than 1.6, then the maximum lags can be used as the number of lags in the ADF test. Another approach was specified by Schwert (1989) as a rule of thumb which is the application of the formula int{12(t/100)1/4} which calculates the integer part and multiplies a 12 period (monthly) seasonality with the total number of observations in the sample divided by 100, and further multiplies the result by 1 over quarterly seasonality, t is the number of observations in the sample. Based on Schwert's rule of thumb, the number of lags selected = 4.

If two or more series are individually integrated but some linear combination of them has a

lower order of integration, the series is referred to as being cointegrated and tests for cointegration assume that the cointegrating vector is constant during the period under consideration. An $mx1$ vector time series Y_t is said to be cointegrated of order (d, b), $CI(d, b)$ where $0 < b \leq d$, if each of its components series Y_it is $I(d)$ but some linear combination $\alpha' Y_t$ is $I(d-b)$ for some constant vector $\alpha \neq 0$ where:

- α: Cointegrating vector or long-run parameter
- The cointegrating vector is not unique. For any scalar c

$c\alpha' Y_t = \alpha *' Y_t$ is $I(d-b) \sim I(d-b)$

The null hypothesis for testing cointegration is that no cointegration exists and the Johansen cointegration rank test for nonstationary vector processes will be used.

3.7. Granger Causality Testing

We will be testing the hypothesis that there is a statistical significant connection between exchange rates and stock prices and these series move through time roughly following a random walk of movements or changes with no immediately discernable pattern of trend, these random walks will be used as a model for stochastic processes. Linear regression cannot be used on non-stationary time series data as this could produce spurious correlation and standard de-trending technique which may include calculating the rate of change of the series through time can result in data that is still non-stationary. Clive Granger has shown that to eliminate the problem of spurious correlation, co-integration testing provides the superior alternative, and variables will be co-integrated if there is a long-run relationship between them (Granger *et al*., 2000).

The Engle-Granger test is therefore applied to test for cointegration and avoid the spurious regression problem. The Engle-Granger test is applied as alternative to Johansen's test due to limitations of Johansen's test which relies to a large extent on asymptotic properties (Sjo, 2011). This method will estimate the long-run equilibrium relationship by applying the Engle-Granger unit root test for the estimated residuals. The null hypothesis for this test will be that the series has a unit root or is non-stationary. The alternative hypothesis will be that the series has no unit root and the rejection of the null hypothesis will imply that the series is stationary and conversely if the null hypothesis is not rejected, a conclusion can be made that the series is non-stationary meaning that the differencing of the series is required.

The next step is then to estimate model parameters on the differenced series which takes the form of a multiple regression model to evaluate and describe the relationship between currency exchange rate and sector indices. The statistical package SAS will be used to compute the Granger causality test using vector autoregression (VAR) model to capture the linear interdependencies for the exchange rate and sector index series. The advantage of a VAR model is that it can be used for forecasting and making structural inferences (Stock and Watson, 2001).

Testing a causal relationship between two stationary series X_t and Y_t then the following two equations can be applied based on the bivariate case (Nath & Samanta, 2003).

(3) $Y_t = \alpha_0 + \sum_{k=1}^{p} \alpha_k Y_{t-k} + \sum_{k=1}^{p} \beta_k X_{t-k} + \mu_t$

(4) $X_t = \varphi_0 + \sum_{k=1}^{p} \varphi_k Y_{t-k} + \sum_{k=1}^{p} \Phi_k X_{t-k} + v_t$

Where:

- p is a positive integer
- α_k's and β_k's, k=0,1,…,p are constants
- u_t and v_t are disturbance terms with zero means and finite variance

3.8. Impulse Response Testing

Granger-causality doesn't always paint the complete picture of the interaction between variables in a system. To improve the understanding of the interaction, impulse responses are investigated to infer the response of one variable to an impulse in another endogenous variable in a system.

4. RESEARCH PLANNING

4.1. Timetable

4.1.1. Resource Requirements

A consultant to proof-read the report before submission.

4.1.2. Risk Analysis

4.1.2.1. Delays in acquiring the data through purchasing or obtaining freely through open resources. The risk mitigation would be to start the process earlier.

4.1.2.2. Delays in receiving comments from the supervisor. The risk mitigation would be to submit drafts as early as possible to the supervisor and provide regular reminders while agreeing on timelines upfront.

4.2. Consistency Matrix

Investigating the dynamic relationship between exchange rate and stock price indices on the Johannesburg Stock Exchange					
Sub-problem	**iterature Review**	**Hypotheses or Propositions or Research**	**ırce of data**	**Type of data**	**Analysis**
Determine if a relationship exists	(Gavin, 1989), (Ma and Kao, 1990), (Jorion, 1991), (Abdalla and Murinde, 1997), (Nieh and (Nucci and Pozzolo, 2001), (Kim, 2003), (Phylaktis and Ravazzolo, 2005), (Kutty, 2010), (Zhao, 2010), (Mayer, 2013), (Darby et al. 1999), (Odhiambo, 2015, Burakov, 2016	The null hypothesis for this test is that the series has a unit root or is non-stationary. The alternative	Quantitative Research / Analysis – ShareNet	Interval and Ratio	VAR model

Table 1 Consistency Matrix

5. PRESENTATION OF RESULTS AND ANALYSIS

5.1. Introduction

The series variables to be used in the analysis were summarized and plotted to understand the nature of the distribution of the series, and to understand the displayed pattern of each individual index plotted against the exchange rate over time. Descriptive statistics were generated to understand the features of the data with measurements of the central tendency (Mean) and measures of variability and dispersion which include variance, standard deviation and range. Statistical methods used to understand the time series relationships are based on various underlying assumptions and one of these key assumptions is the normal distribution of the random variable. Normality cannot be assumed and empirical evidence is required to determine normality of the series distribution and where required, application of relevant transformation techniques to normalize the data.

5.2. Series Plots

The Exchange Rate is plotted against the All-Share Index and individual industry based indices for the period January 2006 and December 2015 to understand the bivariate relationship. Fig. 1 shows the exchange rate and All-Share Index where from 2006 to 2008 the All-Share Index increased sharply while the Exchange rate remained flat. Over the period 2009 to 2015 the two series move in the same direction with the same rate of increase and there appears to be a positive correlation between the 2 series. Fig 2 shows the distribution for the differenced All-Share Index which indicates a slight skewness of -0.198 which is to the left indicating the tail on the left side of the probability density is slightly

longer. Kurtosis is at 0.174 and because it is less than 3 it can be described as platykurtic producing fewer extreme values and has thicker tails compared to a normal distribution.



Figure 1 Exchange Rate and All-Share Index Series Plot

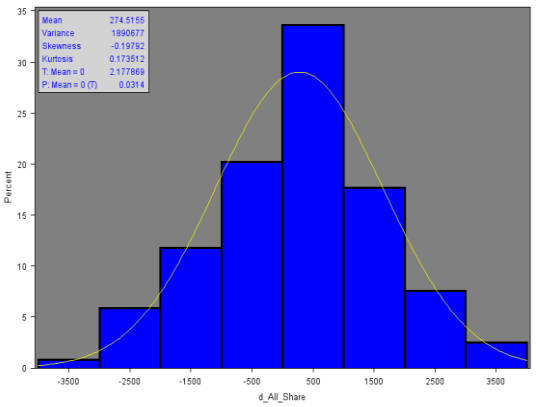

Figure 2 Differenced All-Share Index Distribution Plot

Fig. 3 shows a plot of the exchange rate and Oil & Gas Index where in some periods the two series move in the same direction, and in other periods move in the opposite direction. Fig 4 shows the distribution for the differenced Oil & Gas Index with a skewness of 3.42 which is skewed to the right having more observations on the left. Kurtosis is at 29.99 and because it is greater than 3 it can be described as leptokurtic with a higher peak and thin tails.

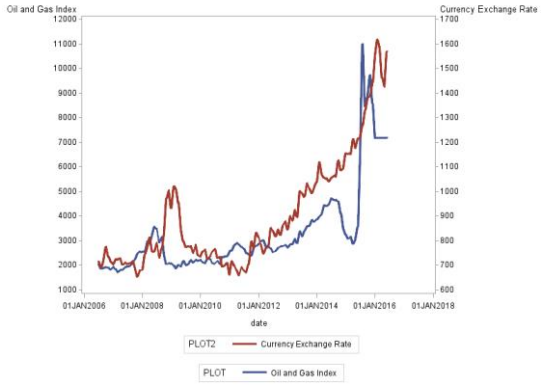

Figure 3 EX and Oil & Gas Index Plot

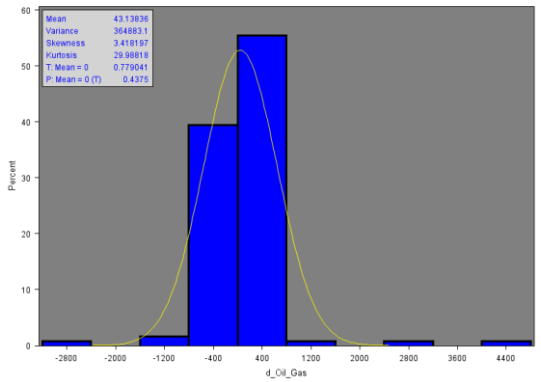

Figure 4 Differenced Oil & Gas Index Distribution Plot

Fig. 5 displays Exchange Rate plotted against the Industrial Index. From 2012 to 2016 the series are moving in the same direction with an increasing pattern. Fig 6 shows the distribution for the differenced Industrials Index with a slight skewness of -0.504 which is to the left indicating the tail on the left side of the probability density is slightly longer. Kurtosis is at 0.655 and because it is less than 3 it has thicker tails compared to a normal distribution

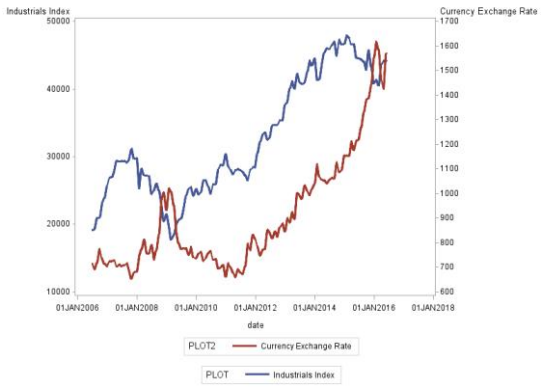

Figure 5 EX and Industrials Index Plot

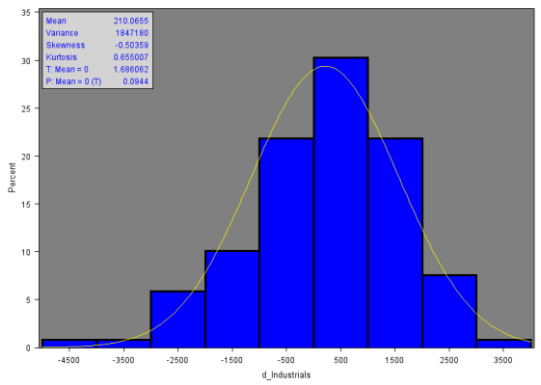

Figure 6 Differenced Industrials Index Distribution Plot

The trend pattern for Exchange Rate and the Health Care Index is an increasing one, with both moving in the same direction. From 2012 to 2015, Health Care Index is however

increasing at a faster rate than Exchange Rate, and this plot is depicted if Fig 7. Fig 8 shows the distribution for the differenced Health Care Index with a slight skewness of -0.271 which is to the left indicating the tail on the left side of the probability density is slightly longer. Kurtosis is at 2.278 which does not deviate substantial to the expected value of 3 of a normal distribution.

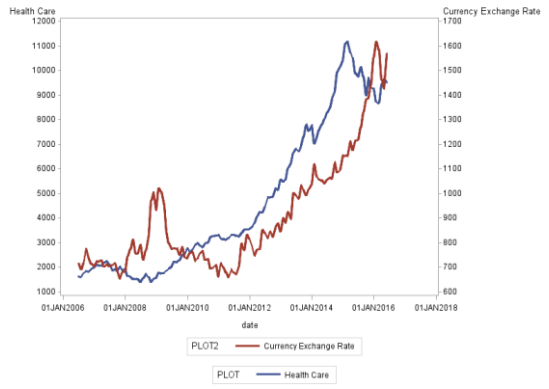

Figure 7 EX and Health Care Index Plot

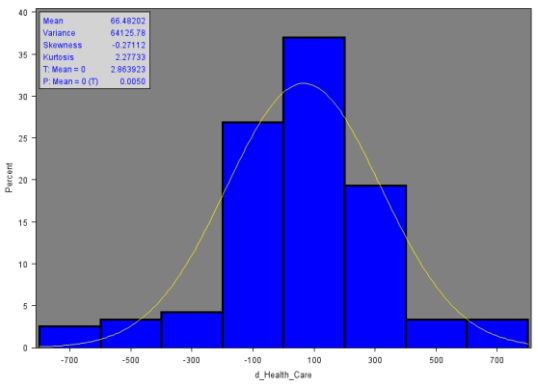

Figure 8 EX and Health Care Index Distribution Plot

Exchange Rate and the Basic Materials Index show an opposite trend as depicted in Fig. 9 where the two are moving in opposite directions and at the same rate, appearing to be mirror images of each other. Fig 10 shows the distribution for the differenced Basic Materials Index with a skewness and kurtosis profile similar to the Health Care Index distribution that does not deviate substantial from a normal distribution with a slight skewness of -0.271 which is to the left indicating the tail on the left side of the probability density is slightly longer. Kurtosis is at 2.278 with fewer expected outliers.

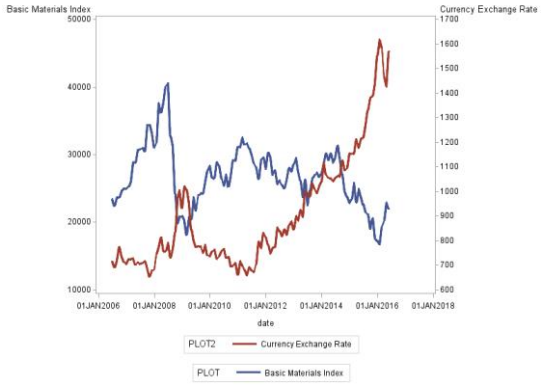

Figure 9 EX and Basic Materials Index

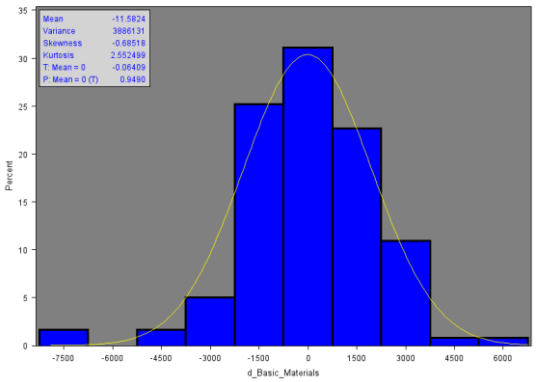

Figure 10 Differenced Basic Materials Index Distribution Plot

Trend patterns for Consumer Services and Consumer Goods plotted against Exchange Rate show an increasing pattern at similar rates in Fig. 11 and 13. Fig 14 and 12 show the distribution for the differenced Consumer Services and Consumer Goods Index which displays evidence of a positive skew of 1.138 and 1.194 respectively and kurtosis results which are slight higher than 3 of 3.368 and 4.047 respectively which would produce more outliers.

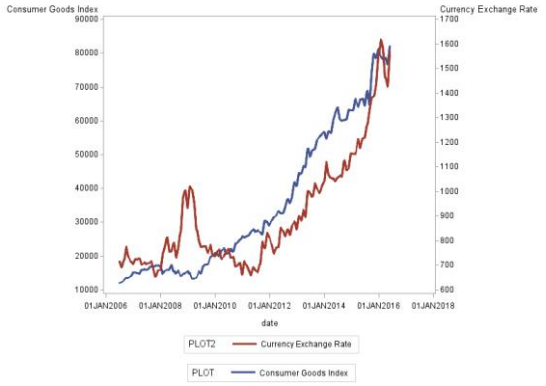

Figure 11 EX and Consumer Goods Index Plot

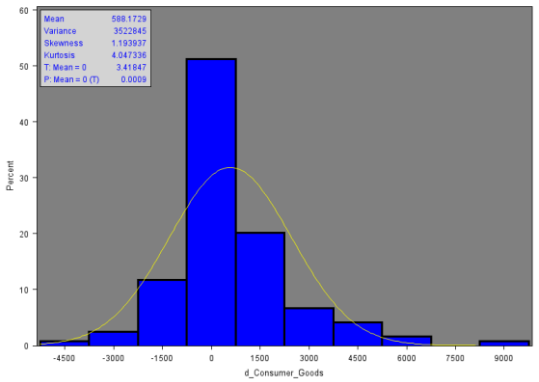

Figure 12 Differenced Consumer Goods Index Distribution Plot



Figure 13 EX and Consumer Services Index Plot

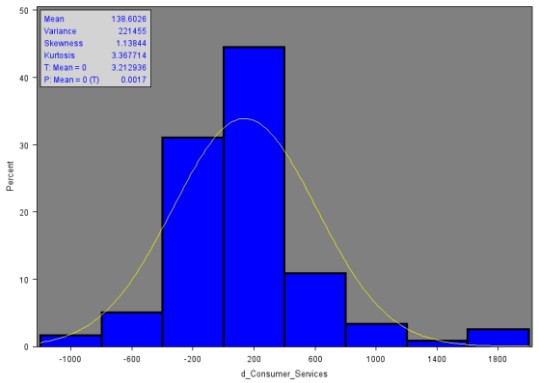

Figure 14 Differenced Consumer Services Index Distribution Plot

Exchange Rate plots against the Technology, Telecommunications and Financial Index follow the same pattern of increasing at the same rate in the same direction as shown in Fig. 15, 17 and 19. Fig 16, 18 and, 20 show the distribution for the differenced Telecommunications, Financials and Technology Index with a negative and a kurtosis of less than 3.

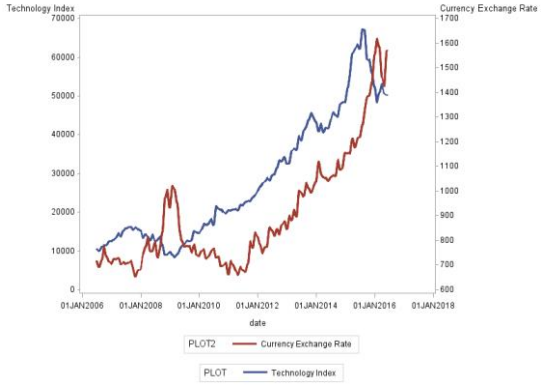

Figure 15 EX and Technology Index Plot

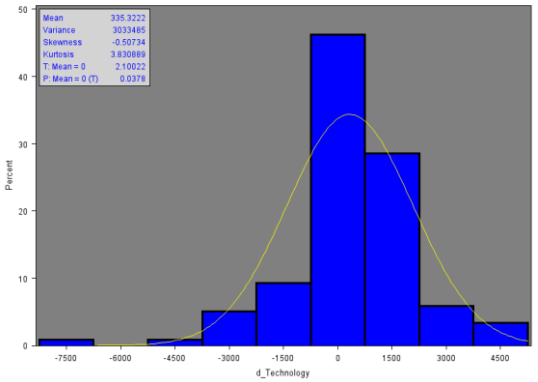

Figure 16 Differenced Technology Distribution Plot



Figure 17 EX and Telecommunications Index Plot

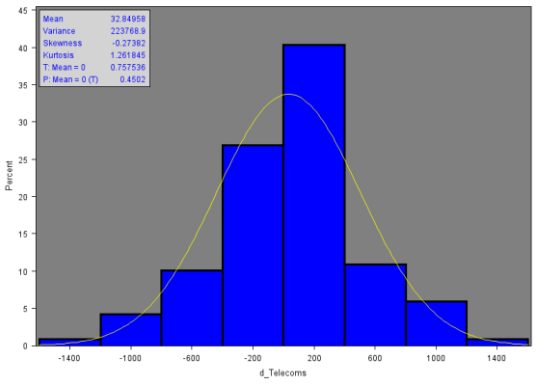

Figure 18 Differenced Telecommunications Index Distribution Plot

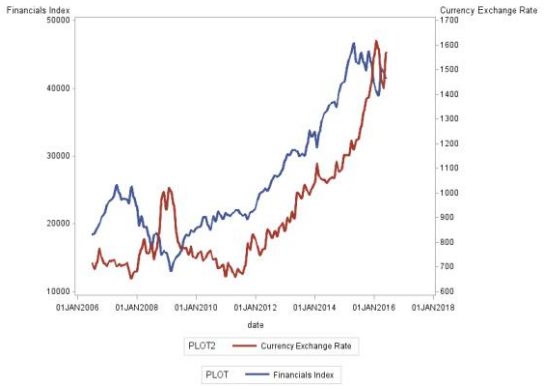

Figure 19 EX and Financial Index Plot

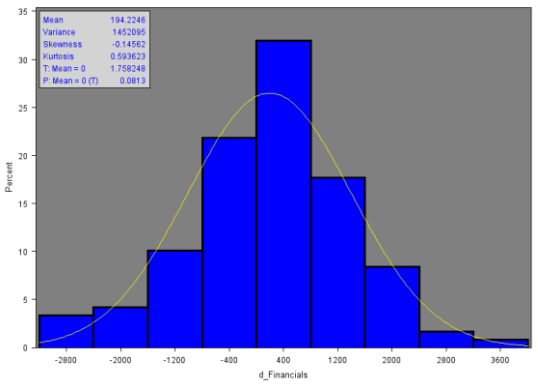

Figure 20 Differenced Financial Index Distribution Plot

5.3. Testing Normality

Table 3 outlines the results generated that are used to run a numerical method of testing the variables for normality. Fields tested for normality include the raw exchange rate variable and JSE indices. The mean provides information about the central tendency of the distribution and is a measure to quantify the amount of variation or dispersion of the variable data values. A low standard deviation indicates closeness of the data values to the mean and a high standard deviation indicates data values that are more spread out, giving some indication of the distribution.

Skewness is a statistic that calculates the direction in which the variable is skewed, and is based on the third moment measuring the degree of symmetry of a probability distribution. A skewness of greater than zero would indicate a distribution being skewed to the right and having more observations on the left. Most of the variables are skewed to the right, with Oil and Gas Index displaying a larger skewness to the right. Kurtosis measures how peaked the distribution is, and is based on the fourth central moment. Like skewness, kurtosis provides an indication of how a variable deviates from a normal distribution.

If kurtosis of a variable is less than 3 or greater than -3, the distribution has thicker tails and a lower peak compared to a normal distribution. If the kurtosis is larger than 3, then this is an indication of a distribution with a higher peak and thin tails. Variable Oil and Gas Index displays a distribution with high peaks and thin tails where the majority of the other variables are closer to 1.

The Kolmogorov-Smirnov (K-S) D test is used to apply the numerical method of testing for normality and is a nonparametric test which is used to compare the distribution of our variables to a reference standard normal distribution. Table 3 summarizes results for the goodness-of-fit test conducted on all the variables. The null hypothesis of a normally distributed variable is rejected for most variables except the Basic Materials Index, at both a 5% and 10% significance level, indicating that Basic Materials Index variable is normally distributed.

The null hypothesis is not rejected for Differenced variables which are normally distributed. The Shapiro-Wilk test, which is more powerful than the K-S test and more suitable for observations less than 2000, was conducted, returning a p value of less than 0.1695. This rejected the null hypothesis.

Variable	Mean	Standard Deviation	Skewness	Kurtosis	Statistic D	Pr > D
All-Share Index	35 230.01	1 045.41	0.4535	-1.1300	0.149	0.010
Oil and Gas Index	3 276.90	1 791.23	2.2691	5.0687	0.231	0.010
Industrials Index	32 714.21	8 862.03	0.2975	-1.3050	0.170	0.010
Health Care Index	4 694.01	3 051.03	0.7088	-0.9852	0.202	0.010
Basic Materials Index	26 807.91	4 539.14	0.3515	0.5931	0.051	0.150
Consumer Goods Index	35 508.34	21 435.19	0.7080	-0.9053	0.171	0.010
Telecommunications Index	7 071.10	2 073.24	0.4835	-0.4569	0.112	0.010
Consumer Services Index	7 309.70	4 853.14	0.9318	-0.4371	0.179	0.010
Financials Index	26 848.86	9 035.93	0.7324	-0.6927	0.162	0.010
Technology Index	28 262.96	16 396.05	0.6957	-0.7363	0.161	0.010
Currency EX Index	904.30	233.07	1.3146	1.0990	0.180	0.010

Table 2 Normality Statistics for Undifferenced series

Variable	Mean	Standard Deviation	Skewness	Kurtosis	Statistic D	Pr > D
Differenced All-Share Index	274.52	1 375.02	-0.1979	0.1735	0.060	0.150
Differenced Oil and Gas Index	43.14	604.06	3.4182	29.9882	0.273	0.010
Differenced Industrial Index	210.07	1 359.11	-0.5036	0.6550	0.093	0.014
Differenced Health Care Index	66.48	253.23	-0.2711	2.2773	0.106	0.010
Differenced Basic Materials Index	-11.58	1 971.33	0.6851	2.5525	0.054	0.150
Differenced Consumer Goods Index	588.17	1 876.92	1.1939	4.0473	0.149	0.010
Differenced Telecommunications Index	32.85	473.04	-0.2738	1.2618	0.104	0.010
Differenced Consumer Services Index	138.60	470.59	1.1384	3.3677	0.165	0.010
Differenced Financials Index	194.22	1 205.03	-0.1456	0.5936	0.057	0.150
Differenced Technology Index	335.32	1 741.69	-0.5073	3.8309	0.110	0.010
Differenced Currency EX Index	7.17	44.45	0.3946	0.8787	0.085	0.036

Table 3 Normality Statistics for Differenced Series

5.4. Unit Root and Cointegration Testing

Results from the unit root test are interpreted at a constant (single mean) and a trend which continues to be a more specific (zero mean and no trend) by looking at the t and F type test. Table 5 summarizes results for all the variables and the F statistic displays results of the test of the hypothesis that $\beta_1 = \beta_2 = 0$. The tau statistics displays results for the test that$\beta_1 = 0$.

Variable	Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
	Zero Mean	4	1.0041	0.9109	2.0495	0.9902		
Exchange Rate	Single Mean	4	2.6217	0.9992	1.3068	0.9986	2.4711	0.4411
	Trend	4	-1.2969	0.9834	-0.3961	0.9866	2.1764	0.7427
	Zero Mean	4	0.7835	0.8705	1.7107	0.9786		
All-Share Index	Single Mean	4	-0.2101	0.9447	-0.1333	0.9423	1.6767	0.6435
	Trend	4	-7.966	0.5735	-1.8794	0.6595	2.0109	0.7758
	Zero Mean	4	-0.0234	0.6759	-0.0115	0.6775		
Oil and Gas Index	Single Mean	4	-8.1467	0.2014	-1.5449	0.5077	1.4781	0.6941
	Trend	4	-29.465	0.0061	-3.0313	0.1283	4.8017	0.2177
	Zero Mean	4	0.5251	0.8108	1.2042	0.9411		
Industrial Index	Single Mean	4	-1.1821	0.867	-0.7083	0.8397	1.2901	0.742
	Trend	4	-6.2954	0.7123	-1.6656	0.7604	1.3927	0.8995
	Zero Mean	4	1.1935	0.9372	1.5747	0.9714		
Health Care Index	Single Mean	4	0.0973	0.9608	0.077	0.9627	1.7967	0.6129
	Trend	4	-7.6092	0.6027	-2.1363	0.5201	2.705	0.637
	Zero Mean	4	-0.5151	0.5652	-0.5363	0.4818		
Basic Materials Index	Single Mean	4	-34.395	0.001	-3.2531	0.0196	5.2959	0.0297
	Trend	4	-44.608	0.0004	-3.7566	0.0225	7.1624	0.0274
	Zero Mean	4	1.802	0.9816	4.6848	0.9999		
Consumer Goods Index	Single Mean	4	1.5969	0.9953	2.5678	0.9999	10.983	<.0010
	Trend	4	-1.7815	0.9742	-0.9956	0.94	5.4435	0.0972
	Zero Mean	4	0.0907	0.7022	0.1289	0.7218		
Telecommunications Index	Single Mean	4	-4.899	0.438	-1.8745	0.3431	1.9727	0.5681
	Trend	4	-9.0642	0.4871	-1.4908	0.8271	1.9833	0.7813
	Zero Mean	4	2.0102	0.9881	5.1324	0.9999		
Consumer Services Index	Single Mean	4	1.8672	0.997	3.0316	0.9999	13.108	<.0010
	Trend	4	-0.8028	0.9898	-0.5346	0.9806	6.6231	0.0422
	Zero Mean	4	0.7	0.8524	1.3979	0.9591		
	Single Mean	4	0.0858	0.9603	0.0554	0.9609	1.0607	0.8005
Financials Index	Trend	4	-5.0725	0.8101	-1.7452	0.7251	2.231	0.7318
	Zero Mean	4	0.6535	0.8418	0.645	0.854		
Technology Index	Single Mean	4	-1.4318	0.8411	-0.7434	0.8306	1.0123	0.8128
	Trend	4	-17.294	0.1036	-2.7063	0.2361	3.6841	0.4412

Table 4 Unit Root Test Results

Looking at the p-values of the autocorrelation (pr < tau), results of the no constant and no trend model type Zero Mean test summarized that we don't have evidence to reject the null hypothesis of presence of a unit root for the trend at a 5% significance level. Therefore the series under consideration have a unit root and are non-stationary random processes. Table 6 summarizes results for the cointegration rank test. The critical values at a 5% significance level are used for testing, and the critical values and test statistics are compared in each row of ranking. From results in Table 4 it appears the time series are cointegrated with rank=9.

H0: Rank = r	H1: Rank > r	Eigenvalue	Trace	5% Critical Value	Drift in ECM	Drift in Process
0	0	0.5871	446.3476	256.23	NOINT	Constant
1	1	0.4823	343.7288	214.07		
2	2	0.4531	267.3565	175.47		
3	3	0.3913	197.347	140.74		
4	4	0.3285	139.7637	109.93		
5	5	0.2379	93.5643	82.61		
6	6	0.1753	62.0501	59.24		
7	7	0.1374	39.6895	39.71		
8	8	0.1113	22.5494	24.08		
9	9	0.0646	8.8577	12.21		
10	10	0.0096	1.1143	4.14		

Table 5 Cointegration Rank Tests

Results from the unit root and cointegration indicate a requirement to ensure the series are made stationary and therefore, differencing is applied and the same tests are conducted. Differencing techniques are normally applied to transform a time series from non-stationary to stationary. Results for normality tests on differenced data are summarized in Table 4. Our variables were differenced and a second round of the ADF test was conducted and results presented in table 7. Table 7 shows enough evidence to reject the null hypothesis of

the present of unit roots. Now that we have achieved stationary, a causal relationship can be investigated. Table 6 summarizes results from the cointegration rank test and it can be concluded that no cointegration is evident in the system.

Variable	Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
	Zero Mean	4	-71.414	<.0001	-4.15	<.0001		
Differenced Exchange Rate	Single Mean	4	-103.96	<.0001	-4.5071	0.0004	10.161	<.0010
	Trend	4	-190.88	<.0001	-4.931	0.0005	12.16	<.0010
	Zero Mean	4	-67.126	<.0001	-4.0573	<.0001		
Differenced All-Share Index	Single Mean	4	-101.69	<.0001	-4.4778	0.0004	10.028	<.0010
	Trend	4	-104.26	<.0001	-4.5093	0.0023	10.259	<.0010
	Zero Mean	4	-294.12	<.0001	-5.3739	<.0001		
Differenced Oil and Gas Index	Single Mean	4	-350.13	<.0001	-5.4408	<.0001	14.801	<.0010
	Trend	4	-410.52	<.0001	-5.4777	<.0001	15.006	<.0010
	Zero Mean	4	-52.241	<.0001	-3.9147	0.0001		
Differenced Industrial Index	Single Mean	4	-62.416	0.001	-4.0846	0.0015	8.3457	<.0010
	Trend	4	-61.644	0.0004	-4.0405	0.01	8.3123	0.0034
	Zero Mean	4	-23.915	0.0003	-2.9159	0.0039		
Differenced Health Care Index	Single Mean	4	-34.041	0.001	-3.3143	0.0166	5.4939	0.024
	Trend	4	-36.606	0.001	-3.3958	0.057	5.7717	0.0799
	Zero Mean	4	-191.05	<.0001	-5.0458	<.0001		
Differenced Basic Materials Index	Single Mean	4	-192.32	<.0001	-5.0254	0.0001	12.628	<.0010
	Trend	4	-215.73	<.0001	-5.0353	0.0004	12.726	<.0010
	Zero Mean	4	-47.54	<.0001	-3.7065	0.0003		
Differenced Consumer Goods Index	Single Mean	4	-239.57	<.0001	-5.1823	<.0001	13.431	<.0010
	Trend	4	575.16	0.9999	-6.2656	<.0001	19.629	<.0010
	Zero Mean	4	-106.27	<.0001	-4.6221	<.0001		
Differenced Telecommunications Index	Single Mean	4	-114.45	<.0001	-4.6479	0.0003	10.824	<.0010
	Trend	4	-148.53	<.0001	-4.8437	0.0007	11.731	<.0010
	Zero Mean	4	-27.309	<.0001	-2.9878	0.0031		
Differenced Consumer Services Index	Single Mean	4	-66.46	0.001	-4.0002	0.002	8.015	<.0010
	Trend	4	-161.66	<.0001	-4.873	0.0007	11.92	<.0010
	Zero Mean	4	-46.872	<.0001	-3.7688	0.0002		
	Single Mean	4	-58.27	0.001	-3.9778	0.0022	7.9173	<.0010
Differenced Financials Index	Trend	4	-65.699	0.0004	-4.1388	0.0074	8.6044	<.0010
	Zero Mean	4	-35.081	<.0001	-3.3921	0.0009		
Differenced Technology Index	Single Mean	4	-43.219	0.001	-3.5916	0.0074	6.4564	0.0024
	Trend	4	-43.806	0.0004	-3.5847	0.0356	6.4296	0.0475

Table 6 Unit Root Testing on Differenced Series

H0: Rank = r	H1: Rank > r	Eigenvalue	Trace	5% Critical Value	Drift in ECM	Drift in Process
0	0	0.6428	517.12	256.23	NOINT	Constant
1	1	0.5409	398.7301	214.07		
2	2	0.4492	309.2087	175.47		
3	3	0.3878	240.6318	140.74		
4	4	0.3125	184.1981	109.93		
5	5	0.3051	141.1066	82.61		
6	6	0.2544	99.251	59.24		
7	7	0.2072	65.4897	39.71		
8	8	0.1739	38.7848	24.08		
9	9	0.0994	16.8102	12.21		
10	10	0.0407	4.7727	4.14		

Table 7 Cointegration Rank Test on Differenced Series

5.5. Granger-Causality Testing

To understand the dynamic relationship between exchange rates and the major indices on the JSE, we have proposed a Granger-causality test which provides the characteristics of the causality between components of a multivariate time series. Several relationships were tested on the variables Exchange Rate (ER), All-Share Index (ALSI), Oil and Gas Index (OGI), Industrials Index (II), Health Care Index (HCI), Basic Materials Index (BMI), Consumer Goods Index (CGI), Telecommunications Index (TI), Consumer Services Index (CSI), Financials Index (FI) and Technology Index (TCI). Table 9 summarizes the causality relationships tested and results found by fitting a VAR (p) model using all the variables defined in Group 1 and Group 2. The null hypothesis of the Granger causality test is that Group 1 variable(s) is influenced only by itself and not influenced by Group 2 (SAS Varmax Proc). If the hypothesis test does not result in rejecting the null hypothesis, then the variables listed in Group 1 might be considered as independent variables.

At a significance level of 10%, the null hypothesis of no causality cannot be rejected for all tested Group 1 and Group 2 variables except for ER ⟶ ALSI, ER ⟶ II, BMI ⟶ ER and CSI ⟶ ER. The results entail that there is unidirectional causality where Exchange Rates Granger-causes All-Share Index and Exchange Rates Granger-cause Industrial Industrials Index. The opposite relationship with Exchange Rate is observed with Basic Material Index, where Basic Material Index Granger-causes Exchange Rates, and Consumer Services Index Granger-cause Exchange Rates. These variables that have a causal relationship with Exchange Rate can be used to build a VAR model to be used for forecasting.

Test	Group 1 Variable	Group 2 Variables	DF	Chi-Square	Pr > ChiSq
1	ALSI	ER	1	5.28	0.0216
2	OGI	ER	1	0.35	0.5531
3	II	ER	1	5.75	0.0165
4	HCI	ER	1	0.94	0.3316
5	BMI	ER	1	2.22	0.1365
6	CGI	ER	1	0.61	0.4358
7	TI	ER	1	2.12	0.1458
8	CSI	ER	1	0.33	0.5674
9	FI	ER	1	0.47	0.4948
10	TCI	ER	1	0.82	0.3652
11	ER	ALSI	1	0.38	0.5356
12	ER	OGI	1	0.03	0.867
13	ER	II	1	1.44	0.2293
14	ER	HCI	1	0.58	0.4479
15	ER	BMI	1	3.57	0.0588
16	ER	CGI	1	0.25	0.614
17	ER	TI	1	0.6	0.4367
18	ER	CSI	1	2.76	0.0966
19	ER	FI	1	0.01	0.9136
20	ER	TCI	1	2.29	0.1302

Table 8 Granger Causality Testing

5.6. Impulse Response Testing

From the results depicted in figure 21, it is evident that the Basic Materials Index shock on exchange rates will have an initial negative effect over 1 period and the impact seems to stabilize over the rest of the periods. Also in figure 21, the Consumer Services Index shock impact on exchange rate is depicted, showing a similar negative effect on exchange rate for the first period but seeming to increase in the next several periods, eventually stabilizing. The negative impact of a unit change of Consumer Services Index on exchange rate is much larger than the Basic Materials Index shock and significantly more positive after the first period.

Figure 22 depicts the impact of the All-Share Index and Industrials Index unit change on exchange rate over time. The All-Share Index has an initial negative impact for the first period after an initial shock, after which the impact fluctuates from negative to neutral over the remaining periods under consideration. The industrial Index has a similar pattern reflecting the impact after a shock, with the average impact being negative over the period under consideration (6 lags). For both outlined relationships, in relation to exchange rate as an impulse and as a response, the impact after the initial shock gradually evens out with the All-Share and Industrial Index appearing to require more periods to stabilize. The stabilizing of the impacts after the initial shock are indications that the systems are relatively stable.

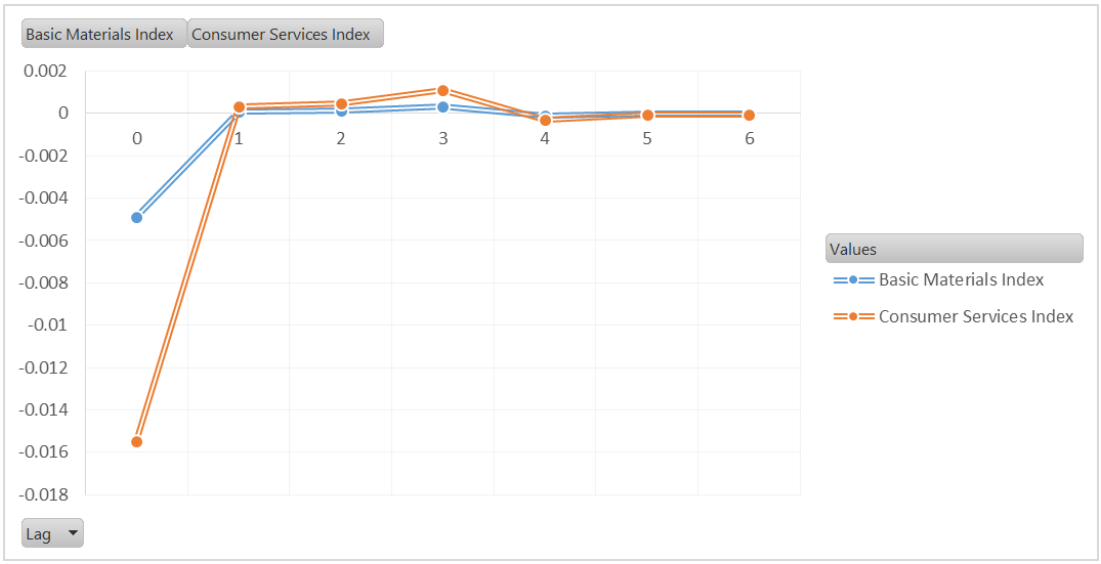

Figure 21 Impulse Response Test for Basic Materials Index and Consumer Services Index on EX

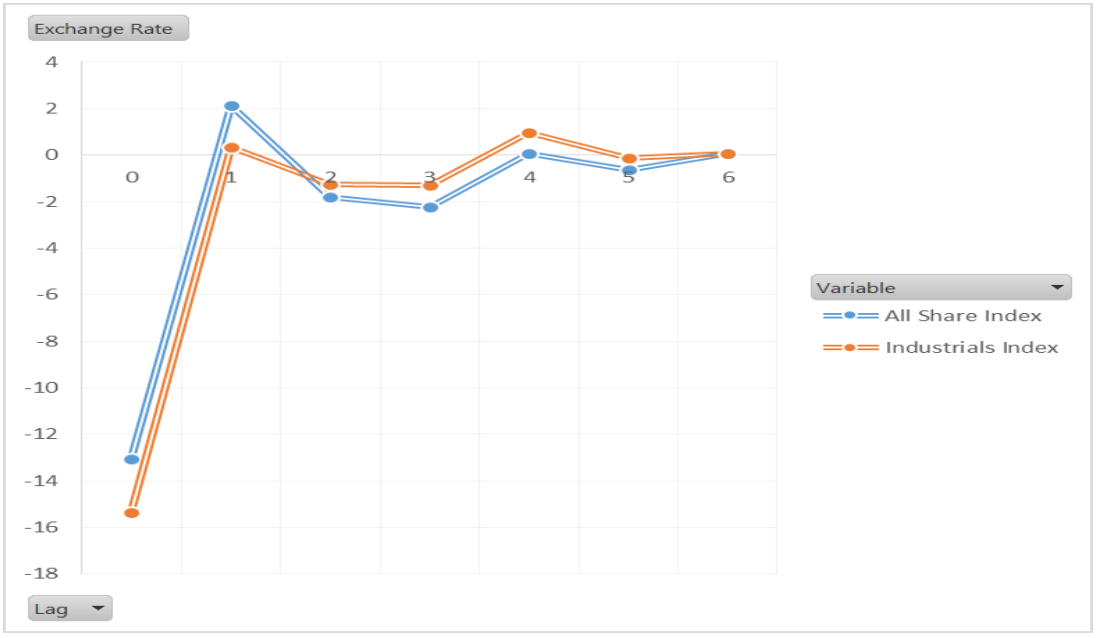

Figure 22 Impulse Response Test for EX on All-Share Index and Industrials Index

6. DISCUSSION OF RESULTS

The JSE sector classifications are based on the Industry Classification Benchmark (ICB), which provides a service to investors by grouping companies in homogenous sectors. The allocation of companies to sectors depends on the company's class of business. The All-Share Index is designed to represent the performance of South African companies listed on the JSE and represents 99% of the full market cap value. It would therefore consist of all companies across different sectors, weighted based on market capitalization. Studies looking at the relationship between the currency exchange rate and the stock market have always looked at the broader stock market index, with mixed results. The most notable studies using data from emerging economies that found a statistically significant relationship between currency exchange rate and the stock market include (Granger *et al*., 2000; Zhao, 2000; Kutty, 2010; Abdalla and Murinde, 1997).

Several indices have been found to have a causal relationship with the currency exchange rate, the All-Share Index, Industrial Index, Basic and Materials Index, and Consumer Services Index. Results showed exchange rates Granger-causing All-Share Index and Industrial Index which is consistent with findings from Kutty (2010) and Granger *et al*. (2000) based on the analysis of Philippines data. The result of the All-Share Index leading currency exchange rates can be explained from the view point that changes in the exchange rate will affect the following factors: the competitiveness of firm on the stock exchange; the value of earnings, future payables or receivables in foreign currency; and interest payments, as many companies borrow in foreign currencies to fund their operations, and therefore the stock price.

Profitability of firms with less market power is more affected by shocks to the exchange rate. Investment decisions of firms with lower monopoly power are more sensitive to exchange rate variations. Investment decisions for smaller firms are more sensitive to currency value fluctuations than those for firms with a greater ability to adjust their cost-price margins (Nucci and Pozzolo, 2001). Mac and Kao (1990) note the foreign exchange risk types; these are from investment returns where transactions are stated in foreign currency terms, and economic exposure linked to the expected future cash flows when the exchange rate fluctuates. As long as the investment is denominated in foreign currency, all investors are invariably confronted with transaction exposure, and therefore the investment will be more attractive if denominated in a stronger foreign currency.

If the core investment is denominated in a strong currency, foreign investors expect to receive a higher rate of return after the payoff is converted into local currency (Mac and Kao, 1990). Exchange rate volatility can have an important negative impact on investment (Darby, Hallett, Ireland, & Piscitelli, 1999). As noted by Nath and Samanta (2003), exchange rate fluctuation on the stock market seems to depend on both the importance of country's international trade in the economy, and the degree of trade balance. South Africa has benefitted from a significant interest in emerging markets, resulting in substantial capital inflows driven by high returns potential on the domestic equity and bond markets. In addition, currency appreciation negatively affects domestic stock market for an export-dominant country and positively affects domestic stock market for an import-dominant country.

The domestic stock market reacts favourably to expected currency appreciation if the economy is primarily import based. The opposite is true if the economy is export based,

where companies will lose competitiveness on the international market if the local currency appreciates. South Africa is an import based economy with imports having increased substantially by 9.6% over the period 2001-2007. Growth in exports was approximately half of that of imports over the same period, and was recorded at 4.1%. It further decreased to -1.4% over the period 2008-2012. The increase in imports was primarily driven by robust household consumption expenditure and rapid growth in investment activity over the period.

There has been a significant growth in the South African black middle-class with increased spending power and access to credit seeking products and services that the domestic market cannot fulfill, resulting in increased demand for imports. Another important point that assists in explaining the increased demand for imports is that our local manufacturing sector has been declining. Manufacturing forms part of the secondary sector accounting for around 18% of GDP, of which Manufacturing dominates this category, and is broadly the fourth largest sector in the economy.

The secondary sector's contribution to GDP has decreased from 28% in 1994 to around 19% in 2012.The tertiary sector, dominated by financial services, accounted for a 12% share in 1994 of GDP, and has grown to 22% in 2012. On the export front, local businesses have historically faced a challenging operating environment, including factors such as rising operating costs; and safety and industrial actions causing production stoppages in the mining sector, which is a major contributor to the export market. In addition, the mining sector decreased in contribution to GDP due to mineral regulations, insufficient supporting infrastructure, eroding skills base and cost pressures.

The Granger Causality analysis indicated exchange rate Granger-causing the Industrial Index on the JSE which has a significant international exposure. The Industrials Index (J520) consists of companies operating within the Construction and Materials, and Industrial Goods and Services (which include the structure of the South African economy) with significant exposure to international markets. The manufacturing sector dominated exports to the US (73%), followed by Mining (26%) and agriculture. The leading manufactured export categories include motor vehicles, basic iron and steel, parts and accessories for motor vehicles, and Basic Materials. Basic Materials Index consists of Chemicals, Forestry and Paper, Industrial Metals and Mining; and was found to Granger-Cause currency exchange rates. As indicated, mining forms a significant part of exports to the U.S and has not been performing well in comparison to competing markets internationally. The Manufacturing sector, in addition to the Mining sector, has been experiencing significant job losses.

In terms of the causal relationship of Consumer Services Index on currency exchange rates, Consumer Services Index consists of Retail, Media, and Travel and Leisure. The Services sectors constitute the tertiary sector, dominated by financial services sector that accounted for 22% of overall GDP in 2012 (as pointed out in the earlier section). The Services sector has experienced sharp growth and is currently the pillar of the overall economic growth. This growth and domestic demand has been underpinned by robust household consumption expenditure; rapid growth in foreign direct investment, which accounts for the majority of capital inflows into South Africa; access to debt; and the widening of the black middle class base. These have led to an increase in demand for imported consumer items and capital goods, which are the dominant categories of businesses accounting for the Consumer Services sector. The penetration of foreign consumer products into the local market and the

demand for products and services from international markets has been underpinned by the relatively strong Rand. The Rand has been on a weakening trend from 1994, and experienced a sharp depreciation in 2008 as the global financial and economic crises intensified.

All these factors seek to explain the results obtained that point to a significant relationship where currency exchange rate Granger-causes the All-Share Index and the Industrials Index. The other significant relationship is the finding of Basic Materials Index and Consumer Services Index Granger-causing the currency exchange rate. To get a more complete understanding of the relationship between the indices and the currency exchange rate, impulse response testing is investigated to ascertain the response of one variable to an impulse in another variable. Looking at the relationship between Basic Materials Index and currency exchange rate, results indicate that Basic Materials Index shock on currency exchange rate will have an initial negative effect over 1 period, with the impact reaching equilibrium over the rest of the period.

Subsectors of Basic Materials are the main export items consisting of Chemicals, the Mining sector, and Forestry and Paper. Volatility of the main export items will lead to both lower confidence and lower demand for the Rand, which leads to a depreciation of the local currency in relation to the U.S dollar. This can be interpreted in the context of both Basic Materials and Consumer Services playing a central role in the South African trading environment, where the South African export market is dominated by Resources while the import market is driven primarily by consumer items and capital goods. It is to be noted that a unit shock in the Consumer Services Index has a much larger impact on currency exchange rate than a unit shock from Basic Materials Index. Given that South Africa is an

import dominated economy, we would expect volatility/a shock in consumer demand for consumer goods (where these consumer goods contribute significantly to the composition of the import basket).

7. SUMMARY, CONCLUSION AND RECOMMENDATIONS

The study sought to empirically establish the dynamic relationship between currency exchange rates and JSE indices. JSE indices were considered individually from the all-encompassing All-Share Index level to the individual industry specific indices using data from January 2006 to December 2015. Specific sector level indices that were used to understand the relationship with currency exchange rate include the Industrial Index, Consumer Goods Index, Health Care, Consumer Services, Telecommunications, Financials and Technology. The nominal currency exchange rate for the USD/ZAR currency pair was used with a specific focus on the U.S as a trading partner with South Africa. The Granger Causality was applied to test these different relationships to determine whether one series is useful in forecasting another using vector autoregression (VAR) to capture the linear interdependencies.

The results showed the following:

- Currency exchange rate Granger-causing the All-Share Index and the Industrial Index
- Basic Materials Index Granger-causing currency exchange rate
- Consumer Services Index Granger-causing currency exchange rate

These statistically significant relationships were found to be unidirectional and there was therefore no causality in the reverse direction. Granger causality was not found for all the other currency exchange rate and sector specific indices tested. The short-run dynamic was analyzed to understand the short term impact and unit change/shock of one series on another, with a specific focus on the direction and size of that impact using impulse response testing. The shocks of the exchange rate on the All-Share Index and the Industry

Index were found to be negative and intense, but only lasted for a brief period after which stability in the system was achieved. The impact of both the Basic Materials Index and the Consumer Services Index on the exchange rate was also negative with Consumer Services Index having the more pronounced initial effect.

These results lead to a conclusion that: there is a causal relationship between the exchange rate and indices on the JSE, and the direction of the causal relationship varies according to the type of index. Using the broad JSE All-Share Index, we found that exchange rate Granger-cause the All-Share Index, which is a unidirectional causal relationship. We can further say that, given results from the impulse response analysis, the relationship is negative, i.e.an appreciation of the currency will lead to increase in stock value from an initial unit change of exchange rate, and a depreciation of the currency will lead to a decrease in stock value.

Given that South Africa is a predominantly an import based economy, a currency appreciation will make import less expensive, and therefore, stocks will respond positively, with the positive impact extending to local currency denominated off-shore investment. In addition, funding/debt acquired offshore will be less expensive. It has been shown that the majority of funding acquired by companies on the JSE comes from sources internationally.

The broad inference is that there is a relationship between exchange rate and indices on the South African stock exchange which lead the currency exchange rate. Given the integration of the South African economy into the Global economy, a floating currency, and the extent to which the Rand is traded as an emerging market currency, would implies increased volatility of the Rand. Increased volatility will affect the market value of stocks,

and effective and strategic management of the currency volatility is therefore required to ensure value is not suddenly wiped out in the stock market. It is therefore evident that a strong currency is more beneficial for the stock market and broader economy, given that a well performing stock market will attract foreign direct investment as investors seek high returns.

Therefore a relatively narrow fluctuation band of exchange rate volatility needs to be maintained, and government policies should not seek to weaken the Rand to make South African exports more attractive to the international market. This will ensure that impulse shocks do not suddenly destroy value on the stock market, given that South Africa attracts most of its funds from portfolio flows because of its economic stability. It is important to take cognizance of the fact that investors prioritize minimized risk and low exchange rate volatility, finding this attractive and stable. It therefore can be said that exchange rate volatility is not beneficial for investment and an appreciating currency is more beneficial to the economy than a depreciating currency.

The study is limited to the nominal exchange rate for the USD/ZAR currency pair and a nominal effective exchange rate that takes into account all baskets of currencies of South Africa's major trading partners on a trade weighted basis. These include the European Union, Japan, China, Africa and the rest of the world. Only a bivariate relationship is considered in this study, and from an economic theory perspective, there are other macro-economic factors that would affect the stock market and the exchange rate. These macro-economic factors include interest rates, inflation, government debt, trade balance, etc. To a limited extent, the variability in the stock market can be explained by exchange rates. Furthermore, the bond market was not considered, and there is an opportunity to further

develop this research to include all these additional variables in an attempt to formulate a more complete understanding of the how the stock market is influenced by all these factors.

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