AN ANALYSIS OF THE EFFECTS OF MACROECONOMIC FACTORS AND METALS PRICE CHANGES ON THE JOHANNESBURG STOCK EXCHANGE

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ABSTRACT

This study examines the long run relationships between macroeconomic variables, metals and the Johannesburg Stock Exchange utilizing quarterly time series data from June 1995 to May 2014. The variables examined are the exchange rate, GDP, money supply, industrial production, inflation, the short term interest rate, long term interest rate, Brent Crude oil, gold, silver, platinum, palladium and copper. A Vector Error Correction Model (VECM) is applied to scrutinize potential long run equilibrium relationships and any short run interrelations amidst the variables. The long-run relationships are analysed via the error correction segment of the model. The empirical results illustrate that the JSE has a significant positive long run relationship with the exchange rate, GDP and industrial production, and a significant negative long run relationship with the short term interest rate and gold. The findings of this study are in unison with prevalent research of its sort, as well as prior research carried out in Apartheid South Africa. Five variables are pinpointed as priced risk factors, therefore rejecting the legitimacy of the CAPM in support of the multifactor APT model in post-Apartheid South Africa.

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1 INTRODUCTION

1.1 BACKGROUND

The concept of higher risk higher return is a familiar term in society which is often referred to by both the layman and the financially educated. Several asset pricing models have been developed over the years to try encapsulate and explain the risk return relationship. Arguably the most popular asset pricing model since its development by Treynor (1961), Sharpe (1964) and Lintner (1965), the Capital Asset Pricing Model (CAPM) is favored due to its simplicity, but has however been criticized for its lack of accuracy in explaining cross-sectional asset returns. In light of the shortfalls of the CAPM model, numerous one factor and multifactor extensions have been developed with the aim of correcting for these inaccuracies. Ross (1976) developed one of the initial and popular alternative multifactor models, the Arbitrage Pricing Theory (APT) model. The APT model was developed with fewer and less restrictive assumptions than the CAPM (Van Rensburg, 1997). Both models were built on the premise of the Efficient Market Hypothesis (EMH), which stipulates that a publicly traded security will fully reflect all available information at any given time (Fama, 1965).

CAPM is a single factor model and relies on beta as the sole relevant risk measure. The APT model on the other hand is a multifactor model and includes a number of distinctive factors that impact asset returns. This has led the APT model to be a more theoretically and empirically appealing model due to its greater explanatory ability surrounding the anomalies which arise through the application of the CAPM model (Dhyrmes, Friend & Gultekin, 1984). Supporting evidence was uncovered which illustrates that book-to-market and size are significant factors in predicting cross-sectional asset prices (Fama & French, 1992; Drew, Naughton & Veeraravaghavan, 2003). Additionally, a wide range of unanticipated events impact asset prices, however some to a larger extent than others (Chen, Roll & Ross, 1986). The single factor CAPM and the multifactor APT model are both linear models built on the notion of higher risk higher expected reward. This however only applies to systematic risk as idiosyncratic risk can be eliminated through diversification (Chen et al., 1986).

The downside of the APT model is that with the inclusion of multiple factors in the model, the impact of these factors on the asset prices must be determined. In light of this, there has been a substantial volume of studies probing into the measurement of risk premiums attached to economic factors and their significance or lack thereof. One theory which has arisen is that macroeconomic factors and relative news impacts stock prices (Chen et al., 1986). This theory has resulted in continued divulgence into the relationship between the macroeconomic factors, stock prices and the underlying methodology. Factor analysis techniques were adopted by majority of early APT models as they determine a substantial amount of the risk owing to the factors which are included in the sample under scrutiny. However, this methodology is scrutinized for its inability to determine the nature of common factors as they are considered innately dormant (Maysami & Koh, 2000). An encouraging, alternative approach to factor analysis is the testing of a set of pre-specified macroeconomic factors through the application of various statistical techniques. This allows one to distinguish whether cross-sectional variation of average returns is explained by the sensitivity coefficients attached to these pre-specified factors (Hamao, 1986).

1.2 INTRODUCTION TO METHODOLOGY TO BE ADOPTED

Multiple macroeconomic factors and their respective relationships to stock returns were initially explored by the APT model. The Fama and MacBeth (1973) style cross-sectional regression was utilized by Chen et al. (1986) who paved the way for future empirical studies involving factor determination of the APT. Chen et al. (1986) are responsible for introducing the understanding of the existence of long-term relationships between particular macroeconomic variables and asset prices. Fama (1981, 1990); Ferson and Harvey (1991) provide compounding evidence in favour of macroeconomic factors driving asset prices.

Macroeconomic factors may become risk factors as they influence discount rates (Maysami & Koh, 2000). This in turn could affect the discounted cash flow approach or the present value model. Additionally, this approach could link asset prices to future expected cash flows and discount rates relative to these cash flows (Serfling & Miljkovic, 2011). The present value model enables one to spotlight asset prices and factors' long-run relationships (Humpe & Macmillan, 2009). These long-run relationships may be evaluated with the application of cointegration analysis (Granger, 1986; Engle & Granger, 1987). Cointegration refers to a set of data which is integrated of the same order and forms a stationary linear combination. This stationary linear combination indicates a long-term relationship between the variables (Johansen & Juselius, 1990). Cointegration analysis allows for the development of an error correction model, through which dynamic co-movements amidst variables and long-run equilibriums can be determined (Maysami & Koh, 2000).

The Johansen (1991) vector error correction model (VECM) will be utilized to test for long-run equilibrium relationships between share prices on the Johannesburg Stock Exchange (JSE) and several macroeconomic variables and metal prices. Standard vector autoregressions (VAR) are used to examine the relationship between stock returns and variables and will be initiated, but is flawed as it does not integrate potential long-run relationships and may be subject to misspecification (Mukherjee & Naka, 1995). The cointegration analysis method is able to divulge further into the dynamic co-movements amidst the variables and is thus the more appropriate framework and will be employed.

1.3 HISTORICAL METHODOLOGICAL INSIGHT INTO SOUTH AFRICA

The South African economy has been built and developed around the mining industry (Sorensen, 2011). The gold sector in particular played a substantial role in the development of infrastructure, manufacture and the service industry, with the JSE being established to fund the mining sector. The discovery of gold on the Witwatersrand was the transition from an agriculturally based economy to the largest producer of gold in the world. South Africa is the world number one platinum and Platinum Group Metals (PGM) producer and is responsible for the large majority of world production (Matthey, 2015).

There is a wide selection of macroeconomic variable studies worldwide. However, there is minimal research relating to economic variables and the JSE share prices, and a superior shortage applying the VECM approach to analyse long-run cointegrating relationships. The most significant studies on the effects of macroeconomic factors in South Africa using cointegration techniques were carried out by Van Rensburg (1995, 1998, 1999); Jefferis and Okeahalam (2000). The latter carried out a follow up study on the formers 1965-1995 study over a similar period. The foundation of cointegration techniques within SA has been laid by the aforementioned. This study has joined these methodologies with the significance of the mining sector in South Africa. Subsequently, the objective of this study is to empirically test the relationships between the standard economic variables adopted by the aforementioned studies as well as relevant natural commodities on the JSE to distinguish if significant long-run relationships exist in a post-Apartheid South Africa.

1.4 PROBLEM STATEMENT / CORE RESEARCH QUESTION

This study will empirically test the long-run equilibrium relationship between several macroeconomic factors and metal prices, and share prices on the JSE between 30 June 1995 and 31 May 2014. The factors included in this study as well as the respective definitions are provided in Table 1 below.

Table 1: Definition of Variables

Variable	Definition
Share Price (ALSI)	Natural logarithm of quarterly closing levels on the JSE All Share Index
US Dollar/Rand Foreign Exchange Rate (EX)	Natural logarithm of the quarter end price of US dollars in terms of the SA rand
Gross Domestic Product (GDP)	Natural logarithm of the quarterly level of GDP
Money Supply (M1)	Natural logarithm of the quarterly level of money supply
Industrial Production (INP)	Natural logarithm of the quarterly level of industrial production
Inflation Rate (INF)	Natural logarithm of the quarterly level of the inflation rate
Short-term Interest Rate (STI)	Natural logarithm of the quarterly level of the short-term interest rate
Long-term Interest Rate (LTI)	Natural logarithm of the quarterly level of the long-term interest rate
Brent Crude Oil Price (BCRUDE)	Natural logarithm of Brent Crude measured in SA rands per barrel
Gold Prices (GOLD)	Natural logarithm of the gold price measured in SA rands per ounce
Silver Prices (SIL)	Natural logarithm of the silver price measured in SA rands per ounce
Platinum Prices (PLAT)	Natural logarithm of the platinum price measured in SA rands per ounce
Palladium Prices (PAL)	Natural logarithm of the palladium price measured in SA rands per ounce
Copper Prices (COPP)	Natural logarithm of the copper price measured in SA rands per troy ounce

1.5 IMPORTANCE AND BENEFITS OF THE STUDY

Various methodologies have been utilized in numerous studies worldwide to explore the relationship between macroeconomic variables and/or metals prices and stock prices. However, in the South African context minimal research has been conducted on this relationship, in particular with the utilization of the VECM approach.

The most significant empirical research carried out in the South African context with respect to the relationship between macroeconomic variables and the JSE was carried out by Van

Rensburg (1995, 1998, 1999). Jefferis and Okeahalam (2000) implemented research which explored the same such relationships, and is documented as one of the initial studies to employ the use of cointegration techniques in a South African context. The aforementioned studies sampled a period which spanned the Apartheid era in South Africa - a period during which the South African economy was handicapped by economic sanctions, international trading restrictions and international disinvestment. These studies focused on macroeconomic variables and other than gold disregarded the possible relevance of metal price relationships with the JSE.

This study will adopt the Johansen (1991) VECM in its examination of cointegration among macroeconomic variables and metals prices with the JSE, and will expand the existing body of knowledge of post-Apartheid South Africa. The study will prove handy as it will potentially indicate the importance, or lack thereof, of the variables found to be of significance in previous studies in South Africa. The study includes several variables which were not included in previous research and thus may introduce new variables of statistical significance. The inclusion of these new variables may indicate the significance, or lack thereof, of the mining industry in post-Apartheid South Africa. Significant insight may be gained into stock market responses to macroeconomic factors and/or metals prices in post-Apartheid South Africa.

1.6 DELIMITATIONS

This study could lead to a pricing model, however, defining the pricing model will not be done in this study as only the macroeconomic variables and metals prices will be looked at. This study will focus on the effects of changes in these variables on the JSE, but will be limited to an explanatory model as opposed to developing any form of pricing model.

2 LITERATURE REVIEW

The review of international literature pertaining to the relationships between macroeconomic variables and respective stock indices worldwide allows for the exploration of the relevance, or lack thereof, of macroeconomic variables effects, relationships and significance in each market respectively. The inclusion of common macroeconomic variables across papers provides insight into which factors should be included in the study, and which have proven to be of significance in asset pricing methodologies in each respective market to date.

The literature is structured as follows: A descriptive analysis of the new variables to be introduced into the study will be given, these being the metals which were not included in prior South African literature with regards to the cointegration relationships on the JSE. Early research carried out in the United States (US) will then be addressed. Evidence from internationally developed markets will then be provided, followed by a review of international developing countries. Evidence from Africa and studies relating to South Africa will then be discussed.

2.1 DESCRIPTIVE ANALYSIS OF NEW VARIABLES TO BE INTRODUCED

The fundamental model of supply and demand can assist in the understanding of how commodity markets respond to changes in various exogenous variables. Precious metal prices follow the same fundamentals as other goods when it comes to pricing as is evidenced in respect of gold, silver and platinum (Labys & Pollak, 1984; Radetzki, 1989; Libicki, 1996; Levin, Montagnoli & Wright, 2006; Olivier, 2011).

Precious metals are traded in US dollars, and thus the exchange rate plays a major role for both investors in these commodities as well as for investors in mining companies of these commodities and the mining companies themselves. Evidence illustrates that depreciation in the dollar will lower the price of gold to investors outside of the US and as a result the demand for gold will increase, hence an increase in the US dollar quoted gold price (Levin et al., 2006). One must bear in mind, that in a South African context, a depreciation of the rand against the US dollar will result in an effective decrease in production costs and an increase in revenue resulting in an increase in profits and share price, with an appreciation of the rand having a contrasting result (Sorensen, 2011).

In light of the highlighted exposure of South African companies' stock prices to the volatility of the rand, rand leverage stocks and rand hedge stocks adopt applicable currency hedging strategies to eliminate exposure to unfavourable movements in the strength of the rand. Nonetheless, short term movements in the level of the JSE continues to be dominated by the direction taken by the rand (Barr & Kantor, 2005). However, when the variability of the rand subsides and the currency stabilises, stock prices on the JSE will reflect real valuations of real economic performance.

Investments in the commodities included in this study, gold in particular, are often utilized for their hedging abilities against the US dollar. Focusing on the relationship between the gold price and the exchange rate, Twite (2002); Pule (2013); Capie, Mills and Wood (2005) find a statistically significant relationship between the two - with the two former supporting the proxy of gold being a hedge against the US dollar. In addition to gold - silver and platinum are also good instruments for hedging against the US dollar (Simpson, Svendsen & Chan, 2007). The international gold market has also been uncovered to be influenced by the strengthening or weakening of European currencies (Sjaastad & Scacciavillani, 1996). Over and above being an efficient hedge against currency risk, gold is also a particularly efficient hedge against inflation and political risk (Blose & Shieh, 1995).

2.2 RESEARCH IN THE UNITED STATES

Macroeconomic factors and economic events have been proven to drive asset prices (Fama, 1981; 1990; Ferson & Harvey, 1991). The impact of some macroeconomic factors and economic events have a greater impact on prices than others (Chen et al., 1986). The authors contend that such variables affect stock prices via their effects on future dividends and discount rates. However, Fama (1981) contends that developments in economic activity affects consumption and investment opportunities, and owing to the fact that these developments are priced in capital markets such that price movements are related to innovations in economic variables.

Empirical performance analysis has distinguished that the APT model is superior to the CAPM (Chen, 1983). Several APT empirical studies aimed to determine the number of significant factors that systematically explain asset returns by carrying out factor analysis methods. Over a period of 1962-1972, three or four systematic risk factors were found to be statistically adequate to explain asset returns (Roll & Ross, 1980). Five factors were uncovered to be of statistical relevance in explaining asset returns on the New York Stock Exchange (NYSE) and American Stock Exchange (AMEX) for the period 1963-1978 (Chen, 1983). In contradiction to this, Dhrymes et al. (1985) explain that the period length and size of the stock groups under analysis will define the number of factors required with results varying between three to five factors.

One of the most noted APT tests was that of Chen et al. (1986) who proxied significant economic variables to systematically influence asset returns. The trio recognized industrial production, the spread between long-term and short-term interest rates, change in expected inflation, unexpected inflation, and the spread between high-grade and low-grade bonds to be of significance in affecting equity returns on the NYSE over the period 1958 to 1984. The identification of the significance of these five variables on asset returns resulted in the commonly referred to five-factor model. A latter study revealed domestic variables such as the default premium, short-term interest rate, market dividend price ratio, lagged production growth rate, and term premium are indicators of current and future economic growth (Chen, 1991). These findings support those of Chen et al. (1986) who advocate that domestic variables illustrate forecasting of excess market returns via their macroeconomic forecasts.

A few years prior, relative tests uncovered a strong positive relationship between equity returns and industrial production, money supply, capital expenditure, gross national product (GNP), the interest rate and lagged inflation (Fama, 1981). Investigation of interaction between money supply and US equities utilizing VAR indicated that changes in money supply have significant direct and indirect effects (via real output, the interest rate and inflation) on equity prices variability in the US (Dhakal, Kandil & Sharma, 1993). Additionally, inflation and growth in money supply are positively related to US equity returns, but budget and trade deficits and interest rates (short-term and long-term) are negatively related (Abdullah & Hayworth, 1993).

Complementary studies have also examined the relationship between equity market returns and macroeconomic variables, the results proving to be statistically significantly widespread as can be seen in Geske and Roll (1983); Huang and Kracaw (1984); Chan, Chen and Hsieh (1985); Burmeister and Wall (1986); Beenstock and Chan (1988); Chang and Pinegar (1990); Fama (1990); Schwert (1990); Kryzanowski and Zhang (1992); Chen and Jordan (1993); Black, Fraser and MacDonald (1997); Rahman, Coggin and Lee (1998).

Gold and US assets such as the Standard & Poor's 500 (S&P 500) and the Dow Jones Industrial Average have minimal relation (Dempster, 2008). A minimal to negative relationship between gold and the US market was also established by Ratner and Klein (2008), whereas gold acts as a good diversifying agent against the market (Dempster & Artigas, 2010). Additionally, gold is less susceptible to demand shocks in the US than metals such as platinum which are used mainly for consumption and industry, and therefore is not expected to drop significantly in economic downturns (Conover, Jensen, Johnson & Mercer, 2009).

2.3 INTERNATIONAL EVIDENCE FROM DEVELOPED MARKETS

2.3.1 EUROPE

Building on the foundations laid by Chen et al. (1986) many a study has been produced outside of the US, with the underlying factors being macroeconomic variables. Analyzing the effect of macroeconomic variables similar to those of Chen et al. (1986); Poon and Taylor (1991) found the relationships between macroeconomic variables and equity returns are vastly different in the UK to those found in the US. Testing eighteen macroeconomic factors in the UK with respect to their impact on equity returns in the UK, Clare and Thomas (1994) found the oil price, retail price index, bank lending and corporate default risk to have significant effects on equity returns.

In more recent studies in the UK, Günsel and Çukur (2007) examined the effects of the exchange rate, money supply, inflation, risk premium, and the interest rate and found that macroeconomic factors are relevant and play a significant role in the UK stock market. The pair further revealed differing regression results between industry portfolios indicating that the significance of effects depends on the industry under examination. Additionally, the testing of long-run relationships of internal and external economic factors revealed that consumer price index, interest rates, industrial production and business expectations play a significant role in respect of equity prices in Italy, Germany, Netherlands, France and the UK (Nasseh & Strauss, 2000).

The Greek economy on the other hand has experienced severe downturns in recent years and as a result has been demoted from a developed market to an emerging market status by the

MSCI Inc. (Bloomberg, 2013). Prior to the economic turmoil and downgrade of the Greek economy, Niarchos and Alexakis (1998) investigated the predictive ability of stock market prices with the use of macroeconomic variables on the Athens Stock Exchange. The authors examined this such relationship over a decade beginning in January 1984 and included inflation, money supply and the exchange rate as proxies for macroeconomic variables. The resulting findings indicated a statistical positive correlation between stock prices on the Athens Stock Exchange and all three variables under investigation (Niarchos & Alexakis, 1998). Ioannidis, Katrakilidis and Lake (2005) found supporting evidence of a positive relationship between inflation and stock market returns in Greece over a period of 1985 to 2003. However, Spyrou (2001) uncovered contrasting evidence which indicated that from 1990 to 1995 there was a negative correlation between inflation and stock market returns in Greece – this finding was however for a shorter time period than the Niarchos and Alexakis (1998) and Ioannidis, Katrakilidis and Lake (2005) studies respectively.

Building on the existing literature in the region, Masuduzzaman (2012) examined the short- and long-run relationship between stock prices and macroeconomic variables in Germany and the UK using monthly data from 1999 to 2011 with the application of the Johansen cointegration methodology. The findings indicate that there are cointegrating relationships between stock prices and macroeconomic variables in both Germany and the UK. The findings deduced from the error correction models and the short and long run causal relationship tests were consistent with the majority of other relevant literature for each country respectively. The findings uncover that macroeconomic variables can be utilized to predict stock prices in Germany and the UK. Furthermore, variance decompositions indicate that money supply and industrial production are significant factors in explaining long run forecast variance of stock prices in Germany. On the other hand, the exchange rate and industrial production are significant factors in explaining long run forecast variance of stock prices in the UK (Masuduzzaman, 2012).

Further North, testing the APT on the Finnish Stock Market, Martikainen and Yli-Ollo (1991) adopted both an explanatory factor analysis approach and a pre-specified macroeconomic factor approach. The authors attempted to distinguish how many factors affect Finnish equities and explored two five-year periods, 1977 to 1981 and 1982 to 1986. The authors pre-specified eleven macroeconomic factors and established a sole significant factor for the first five-year period, yet all eleven factors were established to be significant for the second five-year period, thus supporting the utilization of economic factor model analysis. Over the same sample period, Booth, Martikainen, Virtanen and Yli-Olli (1993) examined the APT in Finland, Sweden and the US. In this study however, the authors utilized transformation analysis to examine the intra-country stability of factor patterns over time and across different samples. The results indicated two stable common factors in different samples. Additionally, two common factors were also established to exist among the US, Finnish and Swedish samples. These results inferred relatively poor performance of the APT in Finland and identified one or two factors to be present in the Swedish and US data.

In the US, UK and Germany gold acts as a hedge against equities on average and as a safe haven in extreme market conditions (Mukherjee & Naka, 1995). Additionally, focusing on commodities, Johnson and Soenen (1997) established minimal to negative relation between gold and the market in Canada, France, Germany, Japan, Switzerland, the UK and the US. Furthermore, oil and precious metals have been found to have a relationship with each other, and this relationship is expected to be due to the US dollar / Euro exchange rate as all these industrial commodities are traded in US dollars (Sari, Hammoudeh & Soytas, 2010). The trio distinguished an absence of long-run equilibrium relationships between changes in the exchange rate and spot price returns.

2.3.2 ASIA

In a replication of the Chen et al. (1986) study in Japan, it was discovered that Japanese equity returns are significantly affected by unexpected changes in risk premiums, term structure and expected inflation. Japanese volatility of real economic activity are weakly priced relative to the US (Hamao, 1988). Subsequently, Elton and Gruber (1988, 1989) found that the five factor APT model is superior at explaining and predicting expected returns in Japan than a single factor model. Further investigation into the factors affecting Japanese equity prices revealed that the exchange rate, Brent Crude oil, production index, money supply, call money rate and a residual market error are all relevant determinants in this regard (Brown & Otsuki, 1990). Utilizing cointegration analysis, evidence illustrates that a cointegrating vector exists between equity market returns, money supply and industrial production in Japan (Humpe & MacMillan, 2009). Furthermore, the share price has a positive relationship with interest rates whereas a change in the share price has a negative relationship with the change in the interest rate (Alam

& Uddin, 2009).

Employing the VECM model on the Tokyo Stock Exchange, it was indicated that long-run equilibrium relationships were present between equity prices and all six macroeconomic variables included in the model, namely: money supply, long-term government bond rate, the exchange rate, inflation, call money rate, and industrial production (Mukherjee & Naka, 1995). Adopting the same VECM approach with respect to the Korean equity price indices, the resulting findings illustrate the presence of direct long run equilibrium relationships between the four macroeconomic variables tested (the exchange rate, trade balance, money supply and production index) with each respective index (Kwon & Shin, 1999). However, contrary to Fama, (1981); Geske and Roll (1983) the stock price index is not a leading indicator for economic variables.

Utilizing similar techniques, Maysami and Koh (2000) aimed at determining the presence, or lack thereof, of long run equilibrium relationships between macroeconomic variables and the Stock Exchange of Singapore. The pair's findings indicated that both the exchange rate and interest rate have long run equilibrium relationships with the Stock Exchange of Singapore. Additionally, positive relationships between money supply, inflation and real economic activity have also been uncovered to exist with Singapore equity returns (Maysami, Lee & Hamzah, 2004).

Over a twelve year period from January 2000 to December 2011, Topcu and Unlu (2013) investigated the relationship between composite leading indicators and share prices in Korea. The authors employed cointegration and causality techniques in their study and used a single measure for composite leading indicators as opposed to individual measures for each constituent of the measure. No long run cointegration relationship was found between composite leading indicators and share prices in Korea. Furthermore, the Toda-Yamamoto causality tests indicate bi-directional causality between composite leading indicators and share prices in Korea (Topcu & Unlu, 2013).

2.3.3 AUSTRALASIA

Research of the Australian market conveys that the market is affected largely by monetary variables and the inflation rate (Groenwald & Fraser, 1997). Contrasting evidence was found by Paul and Mallik (2003) who explored the long run relationship between macroeconomic variables and equity prices of the Australian banking and finance sectors over the period of 1980 to 1998. The authors' findings indicated that the inflation rate has an insignificant effect on equity prices in the finance and banking sector in Australia. Alternatively, it was found that gross domestic product (GDP) growth and interest rates are significant explanatory variables within Australian equity markets (Paul & Mallik, 2003).

Focusing more closely on the Australian mining sector it was established that the sensitivity of stock returns and proportions thereof have a small sensitivity to exchange rate movements, intimating that the wealth of mining firms are not as sensitive to exchange rate movements as initially envisaged (Khoo, 1994). Further insight into the Australian market is provided by Faff and Chan (1998) who tested the sensitivity of the market to price changes. The authors established that the sensitivity of Australian industry returns to gold price returns, over and above market returns, to be widespread. Market sensitivity was found to be positive for resource and mining sector industries. The joint effects of an exchange rate and gold price factor were tested, with the gold price factor proving to be dominant. The pair also carried out tests to explain the return on gold stocks beyond that of a market factor, and applied their model to the return of gold stocks in the Australian equity market. Factors such as gold prices, interest rates and foreign exchange rates were explored, with the only variables displaying significant explanatory power for gold stock returns are the market and gold price factors (Faff & Chan, 1998).

Also in Australia, world metal price movements and the proportions of global and specific-volatility in explaining the overall price variation were examined and it was found that shocks which impact the metals market have greater effects on metals that belong to the same group, with the effects on other metals groups being minimal. Furthermore, price volatility can be attributed to global macro-economic factors or can be commodity-specific (Chen, 2010).

Exploring the persistence of price shocks to primary commodity prices over the period 1957 to 1998, it was realized that short-lived ups and downs are a common occurrence in world commodity markets and that price shocks to many primary commodities are long-lasting, with copper shocks lasting six plus years and gold in excess of nine years (Cashin, Liang & McDermott, 1999). The authors uncovered that adverse price shocks to any given primary commodity is likely to oppress prices for an extended period of time. Supporting evidence was uncovered in which a study tested the persistence of shocks to ten commodity prices (gold, silver, platinum, and copper included). The study adopted a General Autoregressive Conditional Heteroskedastic (GARCH) model and established that price shocks to all four of these metals were found to be persistent (Narayan & Liu, 2011).

The relationship between the stock index and interest rate was brought under inspection in a study which carried out empirical research in fifteen developed and developing economies. Alam and Uddin (2009) chose a test period of January 1988 to March 2003, and used monthly data in the implementation of both the time series and panel regressions. The study uncovered a significant negative relationship between interest rates and share prices in Australia, but no relationship between the change of interest rates and share prices was found (Alam & Uddin, 2009).

Shifting attention to New Zealand, Gan, Lee, Yong and Zhang (2006) examined the relationships between the New Zealand Stock Index (NZSE40) and several macroeconomic variables, namely: the inflation rate, short- and long-term interest rates, the exchange rate index, real GDP, money supply, and domestic retail oil prices. The authors focused on a time period of January 1990 to January 2003 and applied the Johansen Maximum Likelihood and Granger causality tests to monthly time series data for the mentioned variables. The impulse response functions illustrate that a shock to the inflation rate has a negative impact on the NZSE40. The Johansen cointegration test shows that long run relationships exist between the New Zealand stock prices and the macroeconomic variables included in the study (Gan et al., 2006). However, the Granger causality test indicates that the NZSE40 is not a leading indicator in New Zealand which may be owing to the fact that the New Zealand stock market is relatively small in comparison to other developed economies' stock markets. The forecast error variance decomposition highlights that the NZSE40 is consistently explained by the short term and long term interest rates, money supply and real GDP (Gan et al., 2006). The authors emphasize that investors investing in New Zealand should focus on these four variables as opposed to the exchange rate and/or the inflation rate.

2.4 EVIDENCE FROM EMERGING MARKETS

2.4.1 BRAZIL, RUSSIA, INDIA AND CHINA (BRIC)

An investigation into the time-series relationship between stock market prices and the exchange rate and oil price was carried out with respect to Brazil, Russia, India, and China (BRIC) utilizing the Box Jenkins Autoregressive Integrated Moving Average (ARIMA) model (Gay Jr., 2008). The results revealed no significant relationship exists between the exchange rate and oil price with each respective stock market for all BRIC countries under scrutiny. The author explains that the lack of significance may be owing to other domestic or international macroeconomic variables influence on stock market returns (Gay Jr., 2008).

Brazil, Russia, India and China came under investigation again when Topcu and Unlu (2013) examined the relationship between composite leading indicators and share prices in emerging markets. The authors employed cointegration and casuality techniques and used monthly data in their sample period of January 2000 to December 2011. Composite leading indicators was represented as a sole measure as opposed to each factor being included in the study individually (Topcu & Unlu, 2013). The empirical findings of the study indicate that long run cointegrating relationship exist between composite leading indicators and share prices in Brazil, Russia and China, but no cointegrating relationship was established in India. Furthermore, the Toda-Yamamoto causality results display existence of bi-directional causality in Brazil and China and uni-directional causality from composite leading indicators to share prices in Russia and India (Topcu & Unlu, 2013).

A recent study which looked at a period of 1997 to 2014, examined the long run dynamic relationship between the exchange rate and stock prices in the BRIC countries (Vanita & Khushboo, 2015). Using daily data in their implementation of the Johansen cointegration test, the authors tested these such relationships for a pre, during and post crisis period. The results illustrate that the stock price and exchange rate track each other closely in Russia and China. Additionally, a significant negative relationship was uncovered between stock prices and the exchange rate in Russia and India (and South Africa) (Vanita & Khushboo, 2015). Furthermore, a long run cointegrating relationship was found between stock prices and the exchange rate in Russia and China for the total period as well as the during crisis period, whereas in the pre-crisis period cointegration exists in Russia, India and China. For all the countries cointegration appears to be lost in the post-crisis period (Vanita & Khushboo, 2015).

The Brazilian stock market was brought under scrutiny in an examination of the causality relationships between macroeconomic variables and the Brazilian stock market (Ibovespa). Grôppo (2004) made use of a multivariate VAR model in which he included the exchange rate, price of a barrel of petrol in the international market, the short-term interest rate, and the industrial production index. He further carried out an analysis of the causal relationship between variables of monetary policy and the Ibovespa and aimed to distinguish the effects of unexpected shocks in these variables to the stock market (Grôppo, 2005). The most notable of the findings was that of the exchange rate being the greatest determinant of the Ibovespa (Grôppo, 2004; 2005). This was also expressed to be the case by Higuchi and Pimenta (2008), however in this study the finding was determined to be statistically insignificant as was the case with the interest rate and inflation rate.

A study focusing solely on the impact of external factors on the development of the Russian stock market was carried out by Fedorova and Pankratov (2010) who included the following macroeconomic variables, namely: GDP, the US dollar exchange rate, net capital movement, and the Brent Crude oil free market price. The EGARCH model revealed that the oil price and the US dollar exchange rate heavily impact Russia's Moscow Interbank Currency Exchange (MICEX) (Fedorova & Pankratov, 2010).

Gaining insight into the Indian market, limited empirical research exists with regard to multi-factor models. However, the majority of the research that has been done in this area has been implemented using cross sectional regression methodologies. The Fama-French model was used by Connor and Sehgal (2001), whereas Balasubramanian and Bharatwaj (2005) utilized factor analysis to illustrate the suitability and superiority of the five factor model in explaining stock return generation in India.

Exploring the relationships between stock market indices and macroeconomic variables in China and India, Hosseini, Ahmad and Lai (2011) focused on the Crude oil price, money supply, industrial production, and the interest rate. The author implemented cointegration and the VECM techniques for the period of January 1999 to January 2009. The results uncovered both short and long run relationships between all four macroeconomic variables and the stock market in China and India (Hosseini et al., 2011). In the long run, the impact of increases in Crude oil prices and money supply is positive in China but negative in India. The impact of increases in inflation on both the stock indices is positive, but the impact of an increase in industrial production is negative in China. In the short run, the contemporaneous effects of the variables proved to be mixed between China and India, however all these impacts were insignificant (Hosseini et al., 2011).

In a study of the Indian stock market (Sensex) over the period April 1994 to June 2011, Naik and Padhi (2012) implemented cointegration tests and a VECM in order to determine the long run relationships between the Sensex and the exchange rate, money supply, the interest rate, industrial production index, and the wholesale price index. The results show that long run equilibrium relationships exist between the Sensex and industrial production, money supply, and the exchange rate, respectively. Additionally, in the long run, there is a positive relationship between stock prices and both money supply and industrial production, but a negative relationship exists between stock prices and inflation (Naik & Padhi, 2012). The relationship between stock prices and both exchange rate and interest rate proved to be insignificant.

India was brought under further scrutiny when the effect of macroeconomic variables on Indian stock prices was tested. However in this study, Sangmi and Hassan (2013) tested these such relationships on the Nifty, Sensex and the Bombay Stock Exchange (BSE 100). The two indices were utilized as the dependent variables, whereas the inflation rate, exchange rate, industrial production, money supply, gold price, and interest rate were utilized as the independent variables (Sangmi & Hassan, 2013). Multiple regression analysis was applied using monthly time-series data over the period of April 2008 to June 2012. The results indicate the presence of significant relationships between macroeconomic variables and Indian stock prices. The most notable of the results are from the tests on the Sensex and Nifty, which indicate that an increase in inflation lead to higher stock prices. However, an increase in the exchange rate had a contrasting impact and resulted in lower stock prices (Sangmi & Hassan, 2013).

2.4.2 ASEAN-5

In a study spanning 11 years from 1985 to 1996, Wongpango and Sharma (2002) investigated the relationship between stock prices in Indonesia, Malaysia, Singapore, Philippines, Thailand and a set of five macroeconomic variables, namely: GNP, CPI, money supply, short term interest rate, and the exchange rate. The authors selected this time period as it corresponds with parallel stock market growth across all five countries under inspection. The findings of the study are widespread across the variables and countries respectively. The stock price was found to be positively related to growth in GNP in the long run, but negatively related to CPI. The authors found a negative long run relationship between stock prices and interest rates in the Philippines, Singapore and Thailand. However this relationship was found to be positive in Indonesia and Malaysia (Wongpangpo & Sharma, 2002). These findings are in support and contrast to Alam and Uddin (2009) respectively, who over a similar time period, January 1988 to March 2003, found stock prices and interest rates to have a significant negative relationship in Philippines, but no relationship in Malaysia. Additionally, the long run relationship between stock prices and money supply was negative in Indonesia and the Philippines, but positive in Malaysia, Singapore and Thailand. Lastly, the long run relationship between stock prices and the exchange rate was positive in Indonesia, Malaysia and Philippines, but negative in Singapore Thailand (Wongpangpo & Sharma, 2002).

Observing the dynamic relationships between macroeconomic variables and Malaysia's Kuala Lumpur Composite Index, Tan, Loh and Zainudin (2006) uncovered that the inflation rate, interest rate, industrial production and the crude oil price have long run relationships with Malaysian stock prices over the period 1996 to 2005. Results further indicated that the inflation rate, interest rate, industrial production and crude oil price are significantly negatively related to stock prices on the Kuala Lumpur Composite Index in the long run.

In a broader view of emerging Asian economies, Kuttner (2008) explored equity prices as a leading indicator in Indonesia, Malaysia, the Philippines, and Thailand for the sample period of 1996 to 2000. The author discovered that in Malaysia and to a lesser extent Thailand, equity prices were linked closely to macroeconomic activity but this was not the case in the Philippines and Indonesia (Kuttner, 2008). Additionally, it was established that Asian equity prices fail to display a systematic relationship with inflation. A possible explanation for this is that inflation followed a random walk for the sample period covered. Furthermore, the VAR model was utilized in order to determine explanatory ability of liquidity – where real short- term interest rates, the depreciation of the exchange rate, rates of change in real reserve money, real narrow money, real broad money as well as real credit were used as proxies for liquidity. The results yielded no presence of explanatory ability from any of the liquidity measures considered with respect to real output and/or stock prices. Thus, it is highly questionable as to whether liquidity (or observable proxies) is an important driving factor in either financial markets or the real economies of the abovementioned countries (Kuttner, 2008).

2.4.3 REST OF ASIA

In 2004, Nishat and Shaheen utilized data dating from 1973 to 2004 and implemented a VECM and a Granger causality test in order to determine the relationship between the industrial production index, consumer price index, money supply, and the value of an investment earning the money market rate with that of the Pakistan stock market. The cointegration relationships between all four variables and Pakistani stock prices proved to be significant. Ali, Rehman, Yilmaz, Khan and Afzal (2010) also identified a cointegration relationship between industrial production and stock prices from June 1990 to December 2008. Additionally, industrial production and inflation are the largest positive and negative factors of Pakistani stock prices respectively (Nishat & Shaheen, 2004). An overlapping paper employing Iterative Non-Linear Seemingly Unrelated Regression methodology uncovered that the exchange rate, world oil prices, trade balance, and unexpected inflation were significant sources of systematic risk (Attaullah, 2001).

An analysis of the long run causal relationships between macroeconomic variables and Pakistan's Islamabad Stock Exchange over a period of January 2001 to December 2010 was carried out utilizing Johansens cointegration methodology. The results showed that the exchange rate, money supply, and the wholesale price index illustrate a significant negative relationship with stock prices, whereas foreign exchange reserves, interest rate, export and the industrial production index have an insignificant negative relationship with stock prices (Rasool & Hussain, 2014). The same such relationship were tested on the Lahore Stock Exchange over a similar period. The VECM revealed that consumer price index has a negative influence on stock returns in the long run. The authors' findings illustrate the contrary for the exchange rate, industrial price index, and money supply which all displayed a significant positive effect on stock returns in the long run (Sohail & Hussain, 2009).

Two separate studies exploring the relationships between macroeconomic variables and stock prices on the Colombo Stock Exchange (CSE) in Sri Lanka were carried out by Gunasekarage, Pisedtasalasai and Power (2004) and Menike (2006) respectively. The former implemented cointegration and VECM methodology over a 17 year period spanning from January 1985 to December 2001 in order to test the short and long run relationships between consumer price index, the interest rate, money supply, the exchange rate and Sri Lankan stock prices. The latter on the other hand built a multiple regression model in order to ascertain the effects of the abovementioned macroeconomic variables on stock prices in Sri Lanka from September 1991 to December 2002.

Gunasekarage et al. (2004) found that the lagged values of inflation, the interest rate and money supply have a significant effect on the CSE. On the contrary, the exchange rate was the sole variable uncovered to have no significant influence on CSE stock prices. Furthermore, it was found that the stock market fails to influence any of the abovementioned variables other than the interest rate. Menike (2006) on the other hand found that all four variables collectively impact stock prices. His results highlighted that the majority of companies report higher R-squared values, thus indicating the higher explanatory ability of macroeconomic variables in explaining stock prices. Interestingly, the author's results are consistent with studies in other emerging and developed countries pertaining to the exchange rate, inflation rate and interest rate in that the three variables have a negative relationship with stock prices on the CSE. It is however noted that stock prices fail to act as an effective hedge against inflation (Menike, 2006).

Shifting attention to Saudi Arabia, VAR and GARCH models were estimated and interpreted by Alshogeathri (2011) in an investigation into the long and short run relationships between the Tadawul All Share Index (TASI) and eight macroeconomic variables from January 1993 to December 2009. The cointegration test highlighted a positive long run relationship between the TASI and money supply, bank credit, and the oil price. Also highlighted was the negative long run relationship with the short term interest rate, inflation, and the US stock market. The interpretation of the VECM results advocates significant unidirectional short run causal relationships between the TASI returns and both money supply and inflation. Furthermore, the same was deduced with regards to the long run relationships between the TASI and macroeconomic variables. Alshogeathri (2011) also discovered that no causal relationship appears to exist between stock market returns and the exchange rate as determined by the Granger causality tests. In addition to this the impulse response function analysis indicated no significant relationship between the macroeconomic variables and TASI returns, whereas the variance decompositions imply that Saudi Arabian stock market returns are independent of the macroeconomic variables (Alshogeathri, 2011).

Investigating the effects of macroeconomic variables on stock returns in Bangladesh, Quadir (2012) implemented an ARIMA model for the period between January 2000 and February 2007. More specifically, the focus of the paper was on the effects of industrial production and the interest rate on the Dhaka Stock Exchange. The ARIMA model exposed a positive relationship between both variables and the stock market returns. The coefficients were however statistically insignificant, potentially owing to the exclusion of a number of influential macroeconomic variables such as the exchange rate, inflation rate, and balance of trade and consumer price index (Quadir, 2012).

In what is considered an application of APT testing on the Istanbul Stock Exchange (ISE), Kandir (2008) analyzed seven macroeconomic variables' contribution to explaining equity returns over the period of 1997 to 2005. The author found that the exchange rate, interest rate and MSCI World Equity Index returns are significant, whereas industrial production, money supply and crude oil prices proved to be insignificant in explaining equity returns (Kandir, 2008). An overlapping study which covered the period of January 2001 to September 2005 was conducted by Rjoub, Türsoy and Günsel (2009) who found a significant relationship between stock returns and the term structure of interest rate, unanticipated inflation, risk premium and money supply. However, the authors highlight that these findings indicate weak explanatory power in certain aspects, and therefore suggest the presence of other more significant macroeconomic variables which have greater explanatory ability in terms of the stock returns on the ISE (Rjoub et al., 2009).

More recently, Büyükşalvarcı (2010) utilized a multiple regression for the period 2003 to 2010 from which he distinguished that the industrial production index, oil price, interest rate, and foreign exchange rate have a negative effect on the ISE, whereas money supply has a the opposite effect. Furthermore, the gold price and inflation rate present no significant effect on ISE stock returns (Büyükşalvarcı, 2010). Ozcan (2012) applied more specific attention to the interconnections between macroeconomic variables and the ISE Industry Index over the period of 2003 to 2012. The Johansen cointegration methodology was adopted and revealed that the gold price, exchange rate, interest rate, money supply, oil price, export volume, and current account deficit all exhibit a long run equilibrium relationship with the ISE Industry Index. Contrastingly, consumer price index failed to present this relationship (Ozcan, 2012).

2.5 EVIDENCE FROM AFRICA

Moving into Africa, the relationship between the real interest rate and stock prices in Egypt were examined using an error correction model. It was established that the real interest rate has a significant impact on the Egyptian Exchange's performance (Omran, 2003). Taking a broader look at Africa, Adjasi and Biekpe (2005) examined seven African countries with respect to the relationship between stock market returns and exchange rate movements. The authors adopted cointegration testing, the empirical results showing that short-run exchange rate depreciation of the local currency leads to decreases in stock market returns in certain countries with long-run depreciation of the local currency producing a contrasting effect.

Implementation of cointegration and a VECM revealed that average crude oil prices, the exchange rate, money supply and the treasure bill rate have significant cointegrating relationships with stock prices in Ghana (Adam & Tweneboah, 2008; Kuwornu, 2011; Ibrahim & Musah, 2014). The relationship between the stock market and inflation is positive, whereas the exchange rate and treasury bill rate have a negative relation to stock prices (Kuwornu, 2011). It is also identified that shocks to money supply, inflation, and the exchange rate explain a significant amount of stock return variance which is persistent over an extended period of time and do not provide any indication of reverting back to normality. Additionally, money supply, inflation, the exchange rate and index of industrial production significantly influence stock prices in the long-run, whereas the exchange rate and interest rate significantly affect stock performance over the short term. It is therefore evident that macroeconomic variables significantly impact stock returns in Ghana, particularly the exchange rate as it is significantly influential in both the short and long run (Ibrahim & Musah, 2014).

In Nigeria on the other hand, majority of studies on stock market growth and/or development concentrate largely on the relationship between the stock market and economic growth (Oyejide, 1994; Nyong, 1997; Anyanwu, 2005; Ogun & Iyoha, 2005). The minority which concentrated on macroeconomic factors and their influence on stock market development are limited, for the most part, to the use of constricted measures (Akpan, Inya-agha & Aya, 2011; Daferighe & Charlie, 2012). These studies adopted the ordinary least squares technique which is subject to spurious estimates, bias of time series data utilized in the regression, high standard errors of the regression, as well as the inability to address possible long run relationships (Granger & Newbold, 1974).

Macroeconomic variables which have been identified as factors which impact the stock market include private capital flows, stock market liquidity, gross domestic investment, income level, the interest rate, exchange rate, inflation rate, and savings rate, as well as the development of the financial and banking sector (Singh, 1997; Levine & Zervos, 1998; Wachtel, 2003; Beck & Levine, 2003; Yartey, 2008). Data for these variables are readily available for Nigeria and therefore allows for the determination of the relevance of these variables in influencing the Nigerian stock market.

In an expansion of the existing literature on the topic in Nigeria, Gunu and Idris (2009) implemented a multiple regression model which indicates that the interest rate, inflation, GDP, money supply, total deficits, and industrial production all impact Nigerian stock prices. The most notable of these macroeconomic variables impacting stock prices were highlighted to be money supply, GDP, and total deficits. Isenmila and Erah (2012) employed cointegration analysis and an error correction model which uncovered that the exchange rate and oil price have a significant effect on both short term and long term returns in Nigeria. Subsequently, the national savings rate, inflation rate, economic growth rates and financial intermediary development have been highlighted to be significantly influential factors in the determination of stock prices in Nigeria (John & Duke II, 2013).

Transferring attention to Kenya, Kirui, Wawire and Onono (2014) implemented a Threshold Generalized Autoregressive Conditional Heteroscedastic (TGARCH) model from which it was determined that a significant relationship exists between the exchange rate and stock returns on the Nairobi Securities Exchange (NSE) over a twelve year period spanning from 2000 to 2012. The relationships between stock returns and GDP, inflation and the interest rate were however insignificant. Over a similar time period Ouma (2014) utilized the APT and CAPM framework, and adopted the ordinary least squares methodology. Money supply and inflation were also uncovered to have a significant relationship with, and are significant determinants of, Kenyan stock returns. The exchange rate was identified as having a significant, negative relationship with stock returns, whereas interest rates are found to be inconsequential in the determination of long run returns on the NSE (Ouma, 2014).

2.6 EVIDENCE FROM SOUTH AFRICA

There is minimal literature in SA which has delved into the relationship between macroeconomic factors and their impact on stock returns on the JSE, in particular with regard to cointegration methodology. Page (1986) tested APT factors using factor analysis over the period 1973 to 1982 and found there to be two priced factors relating to the mining and industrial sectors. Also utilizing factor analysis, Barr (1990) identified that the short term interest rate, gold price, foreign stock markets and local business confidence are statistically influential determinants of stock returns.

Arguably the most substantial inroads into macroeconomic variables and their relationship with the JSE was brought forth by Van Rensburg in his 1995, 1998, and 1999 studies. His initial study illustrated that changes in the gold price, changes in term structure, changes in inflation, and returns on the NYSE form significant linear relationships with equity prices on the JSE. In his latter study, in 1998, the author implemented bivariate Granger causality and correlation tests in order to examine the relationships between economic variables and equity prices on the JSE. This study was focused on the analysis of the effects of three classes of variables, namely: factors that influence discount rates, factors impacting dividends, and international factors (Van Rensburg, 1998). In the last of his three aforementioned studies, Van Rensburg examined the effects of macroeconomic variables and returns on the JSE, as well as on the Gold and Industrial indices of the JSE. The author found gold, the foreign reserve balance, the long-term interest rate, and the balance on the current account to significantly impact all three indices. The price of gold and the exchange rate were only significant with respect to the Gold Index, whereas the short-term interest rate was established to be significant with respect to returns on the Dow Jones Industrial Index (Van Rensburg, 1999). Mangani (2009) attested the findings of Van Rensburg, with respect to the effects of the interest rate and gold on South African equity returns, to be true.

Among the minimal research done on the topic in SA, Jefferis and Okeahalam (2000) carried out a cointegration analysis using quarterly data over the period of 1985 to 1995. The authors found that the South African stock market is affected by domestic economic growth, whereas the effect of other domestic and/or economic factors are dependent on the size, openness and market orientation of the economy. Size and liquidity of the stock market were also highlighted as significant determining factors in this regard. Additional findings indicate that in the long-run the exchange rate and GDP are positively related to equity prices, and long-term interest rates are negatively related to equity prices (Jefferis & Okeahalam, 2000).

The two previous authors focused on an Apartheid South Africa. An additional study in South Africa was carried out by Moolman and du Toit (2005) who examined short term and long term relationships between domestic and international factors and the JSE. The authors implemented a structural model of the JSE utilizing cointegration and an error correction model over the period of 1978 to 2000 which includes a six year post-Apartheid period. The authors' findings illustrate that equity prices on the JSE are cointegrated with variables dictated by the expected present value model of asset price determination (Moolman & du Toit, 2005). Furthermore, important understanding of the functioning of the stock market and the relationships between the stock market and macroeconomic variables in both the long and short term was explicated. The pair's findings indicate that the long term level of equity prices is determined by discounted future dividends, whereas short term fluctuations are effectuated by the rand/US dollar exchange rate, short term interest rate, gold price, the Standard & Poor 500, and a risk premium.

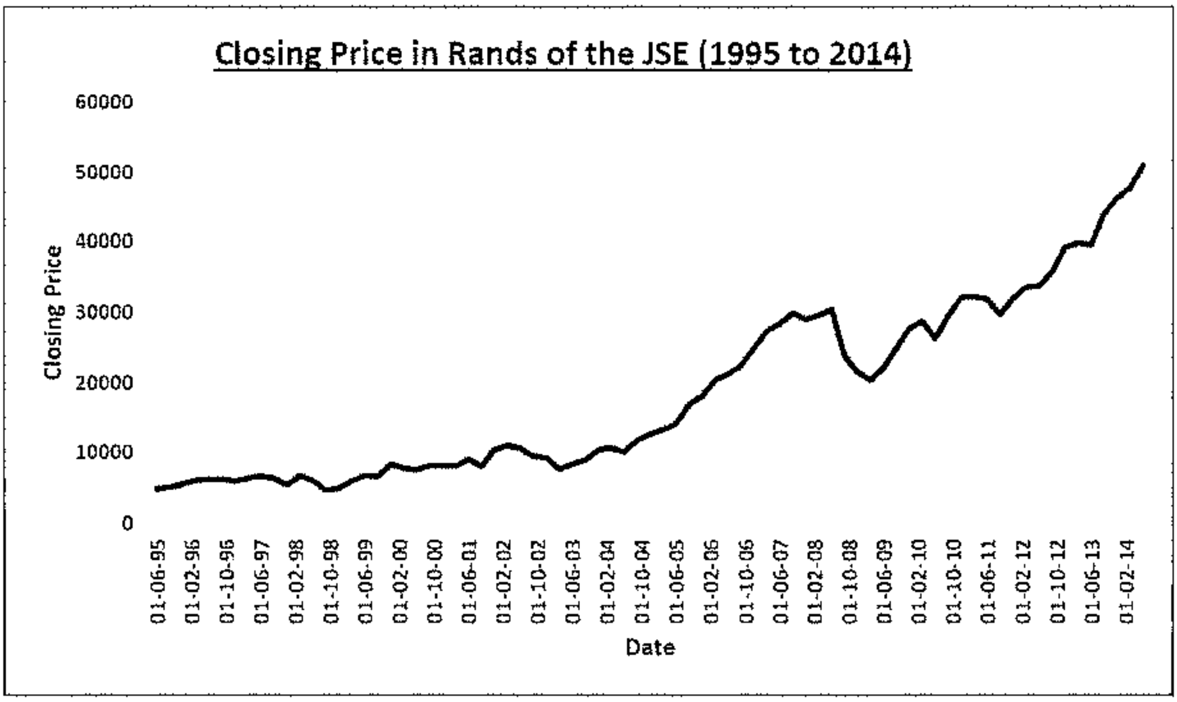
This study will build on the findings of Van Rensburg (1999); Jefferis and Okeahalam (2000); Moolman and du Toit (2005), and will explore the influence of macroeconomic variables and metals prices on the JSE over the period January 1995 to December 2014 using cointegration analysis.

3 RESEARCH DESIGN

3.1 SAMPLING AND DATA COLLECTION

Time series monthly price data for each of the variables considered in the analysis will be used for the nineteen year period, spanning 30 June 1995 to 31 May 2014. The data obtained is from I-Net BFA. This nineteen year period encapsulates a commodity boom and a financial recession. According to Saylor (2014), a commodity boom may be defined "as a general and sometimes precipitous rise in international commodity prices, compared to prices for manufactured products" (p. 33), whereas a recession may be understood as "a business cycle phase in which real GDP decreases for at least two successive quarters" (Parkin, Powell, & Matthews, 2008, p. 795). The nineteen year period stated above is therefore likely to give a good overall representation of the effects of macroeconomic variables and metal price changes on the JSE during different financial and economic periods in post-Apartheid South Africa.

Figure 1: Closing Price of the JSE (in Rands) From June 1995 to May 2014



3.2 HYPOTHESISED RELATIONSHIPS

3.2.1 EXCHANGE RATE (DOLLAR/RAND)

The exchange rate between the US Dollar and the South African rand is of utmost importance in that it significantly affects the relative cost of both imports and exports for locals and foreigners respectively. An appreciation of the rand results in a relative price increase of South African produced products in the international market. This relative price increase results in a decrease of global demand for South African products causing exports and cash inflows to decrease. Conversely, a depreciation of the rand results in a relative price decrease of South African produced products in the international market which results in an increase in exports and capital inflows.

Furthermore, the relationship between stock prices and the exchange rate may be impacted by the extent to which large capitalization companies on the JSE are rand hedge stocks or rand leverage stocks. A rand hedge stock is a company listed on the JSE that is almost completely foreign based, generating revenue and incurring costs only in foreign currency, whereas a rand leverage stock is a company that is South African based and incurs costs in South Africa, but generates income in foreign currency (Barr & Kantor, 2005). In the case of a rand hedge stock, a weaker rand will result in inflated profits when converted into rands, therefore having a positive impact on stock prices. A rand leverage stock on the other hand will realise greater rand-based profit margins when the rand weakens, thus resulting in higher stock prices.

Numerous large capitalization stocks on the JSE are rand hedge or rand leverage stocks. This study therefore hypothesises a positive relationship between the exchange rate and stock prices on the JSE.

3.2.2 GDP

GDP measures the total market value of all final goods and services produced in a country in a given time period – commonly a year (Parkin et al., 2008). GDP growth is one of the key indicators of economic performance. Ceteris parabus, the higher the GDP growth rate the greater the favourability of the stock market. More specifically, greater output levels indicates greater cash flows and corporate profitability which results in higher stock prices. Jefferis and Okhealam (2000) established a positive relationship between GDP and stock prices, therefore this study sets out the hypothesis that there is a positive relationship between GDP and stock prices.

3.2.3 MONEY SUPPLY

Numerous studies have uncovered that money supply significantly impacts stock prices. The direction of the impact remains empirically debatable. An increase in money supply has been established to be positively related to equity returns (Abdullah & Hayworth, 1993). All else equal, an increase in money supply generates excess supply of money and therefore excess demand for equities. This increase in money supply and unchanged quantity of assets causes equity prices to increase. One must bear in mind that an increase in money supply can have the opposing effect to the one described, owing to the positive impact of increased money supply on inflation. This study hypothesises a positive relationship between money supply and stock prices.

3.2.4 INDUSTRIAL PRODUCTION

Industrial production measures the real output of the industrial sector of the economy which includes mining, manufacture and utilities. Industrial production is responsible for only a minor fraction of GDP, but is measured as a separate variable owing to its high sensitivity to both interest rates and consumer demand. Furthermore, industrial production is a significant tool utilized in forecasting future GDP and economic performance. An increase in industrial production is expected to positively impact GDP and corporate profitability, which in turn results in increased equity prices. This was alluded to by Chen et al. (1986) who found a positive relationship to exist between industrial production and equity returns. This study will carry forth the hypothesis of a positive relationship between stock prices and industrial production.

3.2.5 INFLATION

Inflation is an increase in the level of the price of goods and services resulting in a decrease in the value of money and purchasing power (Parkin et al., 2008). Empirical investigation indicates that inflation and stock prices generally have an inverse relationship (Fama, 1981; Chen et al., 1986). The positive effects of expected inflation on interest rates is deemed to have a domino effect on stock prices. Intuitively, inflation increases firms' production costs which decreases future cash flows and therefore depresses the share price. This study will test the hypothesis of a negative relationship between inflation and stock prices.

3.2.6 SHORT AND LONG TERM INTEREST RATES

Interest rates and its underlying volatility are a vital component of asset pricing. Interest rates directly impact asset prices as it effects the applicable discount rates at which cash flows are discounted. There is an inverse relationship between interest rates and asset prices, where a higher interest rate results in a lower asset price and vice versa. A secondary measure in which interest rates affect equity prices is via its effects on equity demand and corporate profitability. This is explained with respect to asset allocation decisions whereby the interest rate may influence the weightings of asset classes within a portfolio which may result in equities being replaced with other financial assets. The replacement of equities within a portfolio will result in a decrease in the demand of equities, hence a reduction in the price of equities. Furthermore, increased interest rates may enforce greater financing costs on corporates relaying into decreased profits and depressed equity prices. Chen et al. (1986) provided empirical findings indicating a negative relationship exists between interest rates and stock prices. This study therefore hypothesises this relationship for both the short term and long term interest rate respectively.

3.2.7 BRENT CRUDE OIL PRICE

South Africa is a net importer of oil which intuitively leads to the understanding that an increase in the oil price will result in increased production costs for South African entities, therefore decreasing profits and share prices. This relationship was alluded to by Filis, Degiannakis and Floros (2011) and has been empirically proven to be negative by Tan et al. (2006) among others. This study hypothesises a negative relationship between the Brent Crude oil price and stock prices.

3.2.8 GOLD PRICE

South Africa is among the leading gold exporters in the world and holds the majority of the world's gold resources and deposits. A significant proportion of the JSE listed companies are resource based and linked to the gold price. The gold price is dollar based and therefore the exchange rate is also of relevance when determining the relationship between the gold price and stock price. An appreciation of the gold price is indicative of an increase in the demand for gold, resulting in greater capital inflows into South Africa. Assuming a constant exchange rate, this study hypothesises a positive relationship between the gold price and stock prices on the JSE.

3.2.9 SILVER PRICE

Silver is a widely produced commodity internationally and is not produced as significantly as gold in South Africa. However, silver is a by-product of gold, lead-zinc, copper and the platinum group metals (PGM). This makes the profits of the mining companies producing these metals as a primary resource susceptible to changes in the silver price. Other factors constant, an increase in the silver price will result in greater profitability for mining companies. This study therefore hypothesises a positive relationship between the silver price and stock prices.

3.2.10 PLATINUM PRICE

South Africa is the leading producer of platinum and platinum group metals in the world and is responsible for approximately eighty percent of world production (Bell, 2015). Platinum is utilized across a diverse spectrum of industries which include jewelry, industrial (in catalytic converters), chemical and electrical to name a few. The price of platinum will have different effects on different industries profits respectively. Platinum producers will experience increased profits when the price increases whereas other companies will experience a decrease in profits when prices rise, and vice versa. South Africa is however a net exporter of platinum and the platinum price will therefore have a distinct impact on South African platinum mining companies' profits. This study hypothesises a positive relationship between the platinum price and stock prices.

3.2.11 PALLADIUM PRICE

Palladium is a constituent of the PGMs and forms a significant proportion of platinum mines' production. The palladium price affects corporate profits in line with the same rationale as that of platinum. This study therefore hypothesises a positive relationship between the palladium price and stock prices.

3.2.12 COPPER PRICE

South Africa produce copper on an industrial scale and are the second largest copper producer in Africa. However, despite South Africa importing a noteworthy volume of copper from Zambia exports still outweigh imports (PMC, 2015). South African corporates are susceptible to copper price changes with an increase in the copper price expected to have a negative impact on corporate profits, and vice versa. This study sets out the hypothesis that there is a negative relationship between the copper price and stock prices.

3.3 METHODOLOGY

The study will identify the effects of macroeconomic variables and metals prices on the JSE using time series econometrics. The analysis can be separated into stationary and non-stationary tests. For the stationary tests quarterly macroeconomic data, metal prices and JSE prices will be logged differenced and tested separately and jointly to establish stationarity.

In order to determine stationarity, the Augmented Dickey Fuller and Phillips-Perron unit root tests will be carried out. The Augmented Dickey Fuller test will be run as opposed to the Dickey Fuller test, as the latter is only valid if the series is an AR(1) process - as a series correlated at a higher lag order violates the assumption of white noise disturbances. Hence, the former will be used as it constructs a parametric correction for higher order correlation by assuming the series in question follows an AR(p) process and adds lagged difference terms of the dependent variable to the right hand side of the equation (Dickey & Fuller, 1981).

3.3.1 VECTOR AUROREGRESSION

Once stationarity is established the variables will be used to estimate a Vector Autoregression (VAR), which is often used to investigate the relationship between economic variables and stock returns, and can be represented by the following equation:

$$Y_t = A_0 + A_q Y_{t-q} + e_t$$

Where Y_t is a vector of the dependent variables. The dependent variables being the JSE, foreign exchange rate, money supply, industrial production, oil prices, inflation, GDP, short-term interest rate, long-term interest rate, and gold, silver, platinum, palladium and copper closing logged prices over the period.

Succeeding the development and approximation of the VAR, the model will be utilized to produce the impulse response functions (IRF) and variance decompositions (Tran, 2006). Impulse response functions enable the determination of structural innovation or shocks and the effect which these have on a variable within the estimated system. Impulse response analysis, however, may be based on the fictional experiment of depicting the marginal effect of a shock to one of the variables within the system. Therefore, the effect of a one standard deviation shock to a dependent variable may be ascertained, as can be the effect on the JSE.

Variance decompositions are used to assist in the decomposition of the proportion to which each variable's variation is determined by a shock or innovation experienced by another variable within the estimated VAR, thus allowing identification of the effect of an exogenous shock to the development of a variable in the system (Stock & Watson, 2001). Variance decomposition analysis will explain the percentage of variation in the JSE that is explained by the variation in the other variables within the system.

The application of the VAR may be preferable when the underlying market structure is complex and uncertain and this approach is advantageous, as it focuses on market uncertainty by isolating fluctuations that are predictable ex-ante from those which are not (Myers, Piggott & Tomek 1990). In support of this, Litterman (1986) established that the VAR models are advantageous as they do not require judgmental adjustments and generate forecasts in conjunction with a complete, multivariate probability distribution for future outcomes of the economy that appears to be more realistic than those generated by other competing approaches. It is further demonstrated that economic forecasting with VAR is a relatively simple, inexpensive to use and attractive alternative in many situations to the use of traditional econometric models and other time series techniques (Litterman, 1986). The VAR model in summation is a solid, authentic tool for data description and forecasting (Stock & Watson, 2001).

3.3.2 VECTOR ERROR CORRECTION MODEL

The issue with stationary time series I(0) is that potentially important information is lost when differencing time series data. A vector error correction model (VECM) analysis corrects for this by using order one (I(1)) non-stationary data. The purpose of the analysis will be to derive the long term relationships between the JSE and macroeconomic variables and metals prices as well as to determine whether any of the factors used are weakly exogenous to the system, implying that they are not significant determinants of the long term variation in the JSE.

Johansen's (1991) cointegration analysis is deemed a more advantageous framework relative to the VAR. This is because the former method has the ability to probe dynamic co-movements among the variables through an error correction model. Furthermore, the VAR analysis becomes erroneous post differencing the data set of time series variables when a cointegrating vector is present (Mukherjee & Naka, 1995). Differencing the relationship of an already linear combination of variables which is already stationary entails a misspecification error (Mukherjee & Naka, 1995).

This study will implement Johansen's multivariate estimation of the VECM as opposed to the two step error correction model (ECM) as it yields relatively more efficient estimators of cointegrating vectors and allows for cointegration testing in a combination of equations in one step (Phillips, 1991). Moreover, the VECM is able to treat all variables as endogenous without requiring the specification of a variable to be normalized. Johansen's VECM indicated better properties than four other estimation techniques of long-run relationships when determined through simulation analysis (Gonzalo, 1994).

Two series, stationary or non-stationary, that result in a stationary error term when combined in a statistical equation are said to be cointegrated (Al-Sharkas, 2004). The Johansen (1991) VECM will be used to evaluate the relationship between the macroeconomic variables, metals prices and the JSE.

It is required that a minimum of two of the variables included in the cointegration system must be integrated of order one (I(1)) in order for cointegration to exist between non-stationary variables (Hansen & Juselius, 2002). To ascertain whether this requirement is met, the augmented Dickey-Fuller (1981) and Phillips-Perron (1998) unit root tests will be run. This is proceeded by the Akaike Information Criterion (AIC) to distinguish the optimal lag length, k, to ensure the residuals of the VECM from each equation are uncorrelated.

The Johansen (1991) VECM equation is described as follows:

$$\Delta Y_t = \sum_{j=1}^{k-1} r_j \Delta Y_{t-j} + \alpha\beta' Y_{t-k} + \mu + \in_t$$

Where:

Δ = First difference notation

Y_t = p x 1 vector integrated of order 1

$\mu = p$ x 1 constant vector representing a linear trend in a system k

k = Lag structure

$\epsilon_t = p$ x 1 Gaussian white noise residual vector

$r_j = p$ x p matrix indicating short run adjustments among variables across p equations at the j_{th} lag

$\alpha = p$ x r speed of adjustment

$\beta = p$ x r cointegrating vectors

A long term equilibrium relationship is found when variables are cointegrated even if Y_t is non-stationary (Mukherjee & Naka, 1995).

The model is estimated by regressing the ΔY_t matrix against the lagged differences of ΔY_t and ΔY_{t-j} and determining the rank of $\pi = \alpha\beta'$. The canonical correlations of the set residuals from the regression equations are used to estimate the eigenvectors β'. The eigenvalues of π, λ_i must be calculated in order to identify the rank of π which in turn gives the order of integration (r). The order of cointegration is tested for using the λ_{trace} and λ_{max} test statistics, which are given by:

$$\lambda_{trace} = -T \sum_{i=r-1}^{p} \ln(1 - \lambda_1)$$

$$\lambda_{max} = -T \ln(1 - \lambda_{r+1)}{}'$$

Where:

λ_1 = Estimated values of the eigenvalues

T = Number of usable observations

The λ_{trace} tests will be used to ascertain the number of maximum cointegrating relationships. The λ_{max} test is used to test specific alternative hypotheses. In the case of π having a full rank in the model, the model will be rejected as this indicates that Y_t has no unit root and hence there will be no error correction (Maysami & Koh, 2000).

Proceeding the determination of the order of integration, is the selection and analysis of the relevant cointegrating vector and speed of adjustment coefficients. In the case where π does not have a full rank and multiple cointegrating vectors are present, the largest eigenvalue is selected. Owing to the fact that this study uses the logarithm of the JSE as the dependent variable, β' will be normalized with respect to the JSE coefficients respectively.

Johansen (1991) also developed the Likelihood Ratio (LR) test which will be performed on the parameters of the cointegrating vector. This is imperative to deduce whether the macroeconomic variables and metals in question have long-term integrating relationships with the JSE. Linear restrictions are imposed by the test on the matrix of cointegrated vectors.

The appropriate null hypothesis is given by:

$$H_0: \beta = H_{\Phi}$$

Where:

$\beta = (p + 1)$ x r cointegrating matrix

$H = (p + 1)$ x s matrix with $(p + 1 - s)$ restrictions

$\phi = (s$ x $r)$ matrix for a case without linear trend

The LR test statistic is given by the following equation:

$$LR = T \sum_{i=1}^{r} ln \frac{1 - \lambda_{H,i}}{1 - \lambda_i}$$

Where:

$\lambda_{H,i} = eigenvalues\ based\ on\ restricted\ eigenvectors$

$\lambda_i = eigenvalues\ based\ on\ unrestricted\ eigenvectors$

This equation follows a χ^2 distribution with r x $(p + 1 - s)$ degrees of freedom.

The concluding tests to be performed within the VECM methodology are the tests for weak exogeneity, and will be performed by imposing restrictions on the speed of adjustment coefficients, with the LR test being used to evaluate if the coefficients are statistically significant.

Essentially, when the variables included within the model are not in long-run equilibrium, there are economic forces which are captured by the adjustment coefficients that drive the model back to long-run equilibrium. Restrictions are placed on the variables within both the cointegrating vector and the speed of adjustment vector. The cointegrating vector is represented by β, and a restriction placed on this such vector denotes the test of long run equilibrium relationships. The speed of adjustment vector on the other hand is represented by α and determines what proportion of disequilibrium is corrected for in one period. An α of one illustrates that the entire disequilibrium is corrected for in one period. In the case of α being less than one, this can be interpreted as the proportion of the disequilibrium error that is corrected for in one time period. Furthermore, an α value which is in excess of one illustrates that the correction surpasses the long-run equilibrium.

In the case of the disequilibrium error between a variable and the JSE not being corrected and thus not being driven back to long-run equilibrium, these variables are deemed to be weakly exogenous to the system and can be excluded from the model.

On completion of the tests for weak exogeneity and determination of statistical significance it will be known as to which macroeconomic variables included in the system are statistically significant and have a long-run equilibrium relationship with the JSE.

4 RESULTS

The results are structured as follows: first the unit root tests will be discussed followed by the impulse response functions and variance decompositions. The cointegration test will then be interpreted proceeded by insight into the VECM and weak exogeneity results. Lastly, a dissection of the long-run equilibrium relationships between significant variables will be analysed.

4.1 UNIT ROOT TESTS

Cointegration requires that variables are integrated of the same order. The augmented Dickey-Fuller and Phillips-Perron unit root tests are used to attest such. Both of these tests were implemented for both the level and first differenced time series data in order to determine the order of integration for each variable respectively. The results are displayed in Table 2 and Table 3 below.

The results indicate that all of the variables, except for inflation, are integrated of order one at the five percent level of significance. In order for cointegration to exist between non-stationary variables within a cointegration system it is requires that at least two of the variables included are I(1) (Hansen & Juselius, 2002). The augmented Dickey-Fuller and Phillips-Perron unit root tests provided results consistent with this requirement.

Table 2: Augmented Dickey-Fuller Test for the Presence of a Unit Root

Variable	ADF Test t-stat	p-value
JSE ALSI (ALSI)	2.0231	0.9999
Δ JSE ALSI (ALSI) *	-6.6203	0.0000
Exchange Rate (EX)	-2.7605	0.0689
Δ Exchange Rate (EX) *	-7.6855	0.0000
Gross Domestic Product (GDP)	-0.2584	0.9250
Δ Gross Domestic Product (GDP) *	-2.9606	0.0436
Money Supply (M1)	2.6182	1.0000
Δ Money Supply (M1) *	-9.3182	0.0000
Industrial Production (IND)	1.1551	0.9976
Δ Industrial Production (IND) *	-7.9881	0.0000
Inflation Rate (INF) *	-3.9624	0.0027
Δ Inflation Rate (INF) *	-7.6354	0.0000
Short-term Interest Rate (STI)	-1.8074	0.3743
Δ Short-term Interest Rate (STI) *	-5.7798	0.0000
Long-term Interest Rate (LTI)	-1.0050	0.7477
Δ Long-term Interest Rate (LTI) *	-9.0066	0.0000
Brent Crude Oil Price (BCRUDE)	-0.2824	0.9218
Δ Brent Crude Oil Price (BCRUDE) *	-7.8048	0.0000
Gold Price (GOLD)	1.0742	0.9970
Δ Gold Price (GOLD) *	-11.4578	0.0001
Silver Price (SIL)	-0.2290	0.9292
Δ Silver Price (SIL) *	-11.2400	0.0001
Platinum Price (PLAT)	-0.2179	0.9307
Δ Platinum Price (PLAT) *	-9.4325	0.0000
Palladium Price (PAL)	-0.2183	0.9307
Δ Palladium Price (PAL) *	-8.4306	0.0000
Copper Price (COPP)	-1.2404	0.6530
Δ Copper Price (COPP) *	-7.7120	0.0000

Notes: Δ denotes the first difference. T-statistics of each test are given with the corresponding p-values.

* denotes significance at the 5% level.

Table 3: Phillips-Perron Test for the Presence of a Unit Root

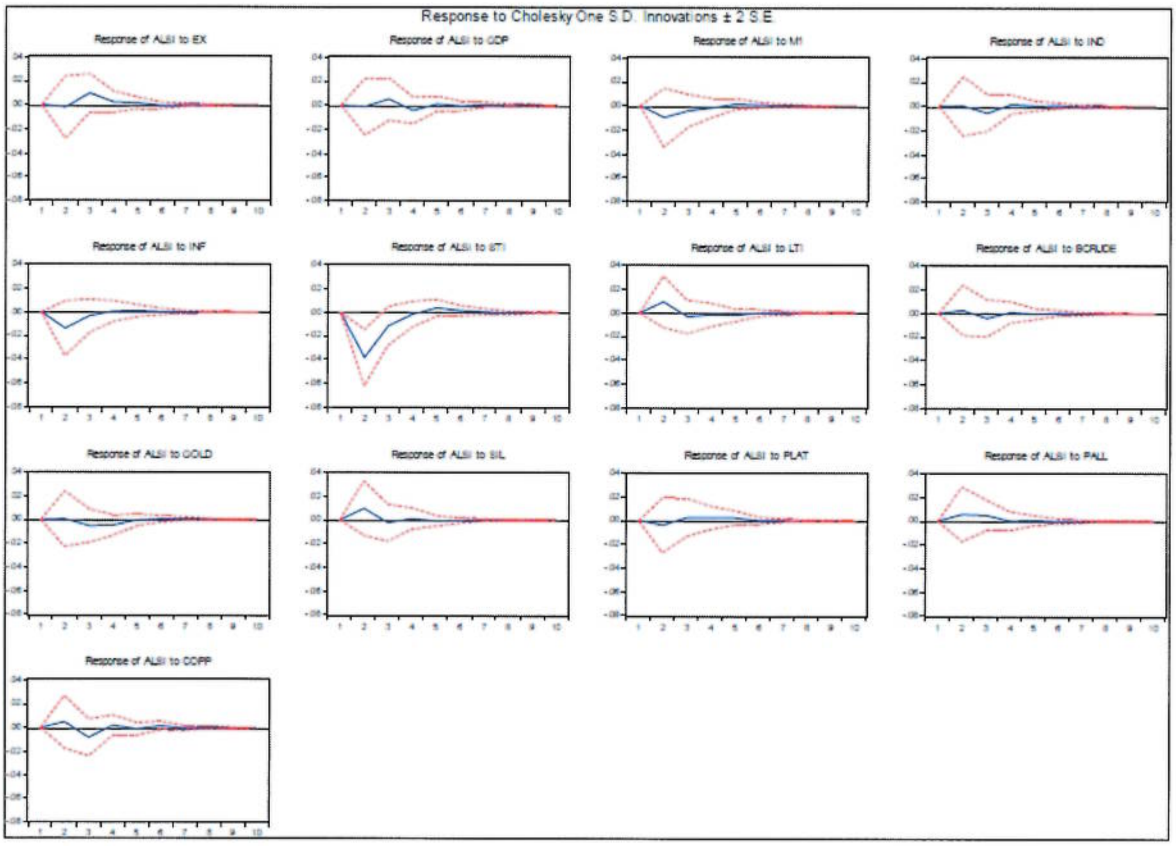
Variable	Phillips-Perron Test t-stat	p-value
JSE ALSI (ALSI)	1.7509	0.9997
Δ JSE ALSI (ALSI) *	-6.6390	0.0000
Exchange Rate (EX)	-2.7279	0.0740
Δ Exchange Rate (EX) *	-7.7064	0.0000
GDP	-0.2262	0.9297
Δ GDP *	-17.6831	0.0001
Money Supply (M1)	2.9725	1.0000
Δ Money Supply (M1) *	-9.4093	0.0000
Industrial Production (IND)	1.1481	0.9976
Δ Industrial Production (IND) *	-8.0061	0.0000
Inflation Rate (INF) *	-3.1617	0.0263
Δ Inflation Rate (INF) *	-6.0672	0.0000
Short-term Interest Rate (STI)	-1.6070	0.4741
Δ Short-term Interest Rate (STI) *	-6.5847	0.0000
Long-term Interest Rate (LTI)	-1.6282	0.4634
Δ Long-term Interest Rate (LTI) *	-9.2232	0.0001
Brent Crude Oil Price (BCRUDE)	0.6230	0.9895
Δ Brent Crude Oil Price (BCRUDE) *	-9.9960	0.0000
Gold Price (GOLD)	1.1525	0.9976
Δ Gold Price (GOLD) *	-11.3104	0.0001
Silver Price (SIL)	-0.3679	0.9085
Δ Silver Price (SIL) *	-11.1430	0.0001
Platinum Price (PLAT)	-0.1340	0.9412
Δ Platinum Price (PLAT) *	-17.2607	0.0001
Palladium Price (PAL)	-0.2183	0.9307
Δ Palladium Price (PAL) *	-8.4306	0.0000
Copper Price (COPP)	-1.1161	0.7057
Δ Copper Price (COPP) *	-8.2464	0.0000

Notes: Δ denotes the first difference. T-statistics of each test are given with the corresponding p-values.
* denotes significance at the 5% level.

4.2 IMPULSE RESPONSES

Impulse response functions are utilized to understand the effect of a positive one-time standard deviation shock to a respective independent variable and the impact which this shock will have on the respective dependent variable (in this case the JSE). Furthermore, the impulse responses enable the determination of the interaction between the variables in the short run. Understanding of the direction as well as the rapidity and persistence of stock market movement to short-run fluctuations of a respective independent variable is attained. The reaction of the stock market to volatility of macroeconomic variables and/or metals prices also illustrates the level of market efficiency. The impulse responses of the JSE to each respective variable for ten quarters is displayed in Figure 2 below.

Figure 2: Impulse Responses Of The JSE



It can be observed from the impulse responses in Figure 2 that a positive one time shock to the exchange rate (decrease in the rand), long term interest rate and silver price increases the closing price of the JSE, however the JSE returns to its pre-shock levels after approximately three to four quarters. A positive one time shock to money supply and inflation has a negative effect on the JSE for about a year before returning to its original levels. Notably, the JSE experiences a large decrease from a positive one time shock to the short term interest rate. The JSE returns to its initial value roughly five quarters after the shock. It can further be observed that one time shocks to GDP, industrial production, Brent Crude oil, gold, platinum, palladium and copper have an insignificant minimal effect on the JSE respectively.

The effects of a one-time standard deviation shock to the JSE on each of the macroeconomic variables and metals prices included in this study was determined respectively (see Section 9.3: Appendix C). A one-time standard deviation shock to the JSE has a negligible effect on the exchange rate and gold price respectively. However, this shock causes GDP to peak after three quarters before decreasing until approximately four quarters, after which GDP returns to its initial pre-shock level. Money supply peaked at around quarter two following a one-time standard deviation shock to the JSE - this positive effect subsided after roughly three quarters. Industrial production on the other hand reached its summit at quarter one before decreasing and returning to its initial levels after a year. Further illustrations identify that a one-time standard deviation shock to the JSE causes inflation, as well as the short and long term interest rates to increase. All three of the variables return to their respective pre-shock levels after approximately two years. Lastly, Brent Crude oil, silver, platinum, palladium, and copper all appear to peak at around quarter one before decreasing and eventually overshooting at around quarter three after which pre-shock levels are realised at approximately quarters four to five.

4.3 VARIANCE DECOMPOSITION

A variance decomposition illustrates a decomposition of the proportion to which each variable's variation is determined by a shock or innovation experienced by another variable within the estimated VAR, thus allowing for identification of the effect of an exogenous shock to the development of a variable in the system (Stock & Watson, 2001). The results of the variance decompositions for the JSE are tabulated and displayed in Table 4. The disturbances ε^{ALSI}, ε^{EX}, ε^{GDP}, ε^{M1}, ε^{IND}, ε^{INF}, ε^{STI}, ε^{LTI}, ε^{BCRUDE}, ε^{GOLD}, ε^{SIL}, ε^{PLAT}, ε^{PALL}, and ε^{COPP} represent the shocks to errors of changes in the JSE, exchange rate, GDP, money supply, industrial production, inflation rate, short term interest rate, long term interest rate, Brent Crude oil, gold, silver, platinum, palladium and copper respectively.

Table 4: Variance Decomposition for the JSE

	S.E.	ε^{ALSI}	ε^{EX}	ε^{GDP}	ε^{M1}	ε^{IND}	ε^{INF}	ε^{STI}	ε^{LTI}	ε^{BCRUDE}	ε^{GOLD}	ε^{SIL}	ε^{PLAT}	ε^{PAL}	ε^{COPP}
Δ ALSI	0.1309	**56.5068**	1.4340	3.1100	0.8996	4.8831	3.1171	16.8070	3.3600	2.7905	0.9513	3.9981	0.8796	0.6077	0.6553
Δ EX	0.1033	3.2131	**63.4125**	0.5808	0.6478	2.8974	1.3553	3.3449	2.0544	3.6370	4.3642	4.4138	7.1074	1.6327	1.3387
Δ GDP	0.0344	3.7307	3.8896	**57.3315**	0.7624	1.4093	2.8291	8.7303	2.8900	3.4322	7.4469	2.1067	2.1468	1.9730	1.3213
Δ M1	0.0454	1.1969	5.5804	14.0628	**41.8055**	2.3519	3.6134	1.9560	0.3274	1.8360	3.6195	5.1009	3.9496	1.1109	3.4889
Δ IND	0.1448	24.0177	6.4952	3.3059	0.4583	**23.6066**	4.7754	11.8125	7.1847	3.4444	2.5109	4.1745	4.1926	3.0488	0.9724
Δ INF	0.5434	6.2303	3.6092	2.5919	7.9356	2.7149	**49.2916**	3.5959	2.4104	12.8392	2.2524	2.2020	2.8751	0.2589	1.1925
Δ STI	0.1209	14.8208	7.0311	5.0434	2.4122	4.0300	12.4881	**40.0106**	1.1182	0.3877	2.0890	5.5448	1.8031	1.4453	1.7757
Δ LTI	0.0964	7.1639	7.8231	2.9679	3.2343	5.1545	13.7209	5.9706	**30.5064**	3.0063	1.6797	1.9273	13.5401	1.5812	1.7239
Δ BCRUDE	0.2373	13.7269	4.2702	6.9503	3.7548	3.5172	6.3224	6.8465	5.8971	**27.8259**	4.6982	1.0183	10.5341	1.4003	3.2378
Δ GOLD	0.1173	4.9712	23.2886	6.0648	0.2675	2.7617	3.4338	2.6515	1.2181	5.4161	**31.4468**	4.1211	12.1560	0.8672	1.3356
Δ SIL	0.1683	6.2819	8.1529	8.3441	2.2860	6.9506	6.6523	7.6724	2.3585	4.9275	14.4100	**25.4365**	5.8009	0.7949	0.9314
Δ PLAT	0.1732	18.7005	13.4401	2.7691	1.4891	9.9833	3.4651	1.9873	1.7979	3.1213	8.0342	2.4233	**30.4391**	2.0324	0.3172
Δ PAL	0.2708	15.6142	11.2345	5.9566	3.8161	3.8228	5.1167	6.2565	0.3878	5.4580	3.1201	3.5884	9.9077	**24.7303**	0.9901
Δ COPP	0.2140	17.6412	8.9108	1.6601	2.8129	4.3794	2.3019	7.0460	10.0588	3.0277	6.3477	3.7488	10.8242	0.6585	**20.5820**

'Notes: Variance displayed in percentages from Cholesky Decomposition test after 10 periods.

The results displayed can be interpreted as follows: shocks to each of the variables dominate the individual variance experienced by each variable respectively, except for industrial production, however the extent to which this dominance is experienced varies across each variable. The JSE, exchange rate, GDP, money supply, inflation and the short term interest rate have a substantial dominance of their own variance decompositions respectively. The contribution towards the variance decompositions for these mentioned variables range between forty and sixty-five percent. The findings are in unison with literature of the sort, in that the majority of forecast error variance within a series is explicated owing to its own variance (Chinzara & Aziakpono, 2009).

The JSE contributes approximately fifty-seven percent towards its own variance decomposition, whereas the short term interest rate is responsible for roughly seventeen percent and is the only variable other than the JSE which contributes more than five percent in this regard. Volatility of the exchange rate is largely independent of shocks to any of the other variables included in the study. This is inferred from the sixty-three percent contribution by the exchange rate towards its own variance decomposition and no other variables contribution being in excess of eight percent. The same such conclusion can be drawn with respect to GDP – approximately fifty-seven percent of the variance decomposition is comprised of variation to

GDP itself and no other variable contributes more than nine percent. Money supply is its own largest contributor with respect to its variance decomposition, contributing approximately forty-two percent. The other variables included in the study are minimal contributors contributing no more than six percent per variable. Inflation is responsible for roughly half of its variance decomposition, while thirteen odd percent comes at the hands of shocks to Brent Crude oil. Shocks to the other variables prove to have a marginal impact on the variation of inflation. The variation of the short term interest rate on the other hand is decomposed as forty percent coming from shock to itself, approximately fourteen and percent twelve percent from a shock to the JSE and inflation respectively.

The results further indicate that a shock to the long term interest rate contributes to about thirty percent of its own variance, whereas shocks to the short term interest rate and platinum contribute equally to a joint twenty-eight percent of the long term interest rates variance decomposition. Brent Crude oil's variance decomposition on the other hand is comprised of approximately twenty-eight percent of a shock to itself and roughly fourteen percent from a shock to the JSE. The variance decomposition of gold is explained by a thirty odd percent shock to the gold price and twenty three percent by a shock to the exchange rate. Twenty five percent of the variance decomposition of silver is explained by a shock to silver itself, while gold contributes roughly fourteen percent in this regard. Platinum's variance decomposition is described by roughly thirty percent and nineteen percent from a shock to itself and the JSE respectively. Shocks to the JSE and the exchange rate determine roughly sixteen and eleven percent respectively to the variance of palladium, whereas palladium contributes to twenty five percent of its own decomposition. The variance decomposition of copper is broken down into twenty-one percent from a shock to itself and slightly less by a shock to the JSE which contributes only three percent less than copper itself.

Notably, industrial production is the only variable included in the study which is explained to a greater extent by a shock to another variable than by a shock to itself as illustrated by its sensitivity to movements in the JSE. The JSE and industrial production are responsible for just over and just under twenty-four percent of the variance decomposition of industrial production respectively.

Interestingly, shocks to money supply, industrial production and the long term interest rate do not account for more than approximately ten percent of the variance decomposition of any variable other than their own. Additionally, shocks to silver, palladium and copper do not account for more than roughly five percent of the variance decomposition of any variable other their own. The impact of shocks to these variables therefore appears to be rather inconsequential in the short term.

4.4 COINTEGRATION TEST

The number of cointegrating vectors generated by the Johansen cointegration may be sensitive to the quantity of lags in the estimated VAR model model (Banerjee, Dolado, Galbraith, & Hendry, 1993). The Akaike information criteria (AIC) is utilized to determine the optimal lag length of the model. The optimal lag length (K) was found to be four (see Section 9.4: Appendix D).

The lag structure was determined using level time series data. However, the cointegration test first differences the data and therefore the lag order must decrease by one from four to three. The results and critical values (CV) for the λ_{trace} and λ_{max} tests for $k = 3$ are displayed in Table 5 below. Both the λ_{trace} and λ_{max} tests reject the null hypothesis for all values up to and including $r \leq 13$ at the five percent level of significance, thus indicating that there are fourteen cointegrating relationships within the system.

As indicated, there is a minimum of one cointegrating vector between the JSE and the macroeconomic variables and/or metals included in the study. It is therefore tenable to assume that a long run equilibrium relationship is present between the variables. It is noted that Johansen (1996) expresses that the λ_{max} is not asymptotically correct, however the concluding results are parallel with those of the λ_{trace} test as indicated previously. In light of the aforementioned, the sole point of relevance remains as to whether any cointegrating vectors are present. It has been indicated and alluded to that there is a minimum of one cointegrating vector, hence there is a long run equilibrium relationship between the variables.

Table 5: Results and Critical Values for λ_{trace} and λ_{max} Test on the JSE

H_0	λ_{trace}	$CV_{(trace\ 5\%)}$	p-value	λ_{max}	$CV_{(max\ 5\%)}$	p-value
r = 0 *	1693.9280	N/A	N/A	368.8218	N/A	N/A
r ≤ 1 *	1325.1060	N/A	N/A	281.2355	N/A	N/A
r ≤ 2 *	1043.8690	334.9837	0.0000	234.0594	76.5784	0.0001
r ≤ 3 *	809.8099	285.1425	0.0000	183.1922	70.5351	0.0000
r ≤ 4 *	626.6177	239.2354	0.0000	170.1313	64.5047	0.0000
r ≤ 5 *	456.4864	197.3709	0.0001	127.4709	58.4335	0.0000
r ≤ 6 *	329.0155	159.5297	0.0000	82.4432	52.3626	0.0000
r ≤ 7 *	246.5723	125.6154	0.0000	68.6272	46.2314	0.0001
r ≤ 8 *	177.9451	95.7537	0.0000	59.6657	40.0776	0.0001
r ≤ 9 *	118.2794	69.8189	0.0000	46.3061	33.8769	0.0010
r ≤ 10*	71.9734	47.8561	0.0001	30.5649	27.5843	0.0201
r ≤ 11*	41.4085	29.7971	0.0015	24.2377	21.1316	0.0177
r ≤ 12 *	17.1708	15.4947	0.0277	12.6747	14.2646	0.0878
r ≤ 13 *	4.4962	3.8415	0.0340	4.4962	3.8415	0.0340

Notes: The critical values for the above statistics are obtained from MacKinnon-Haug-Michelis (1999).
'r' denotes the number of co-integrating relationships.
*denotes the rejection of the hypothesis at the 5% level of significance.

4.5 VECTOR ERROR CORRECTION MODEL

The normalized cointegration coefficients for the JSE estimated from the VECM are shown in Table 6 below. The cointegrating vector equation and resulting cointegrating relationship equation are then illustrated respectively.

Table 6: Normalized Cointegrating Coefficients, Corresponding Standard Errors and t- stats

Variable	Coefficient	Standard Error	t-stat
ALSI	1.0000		
EX	-0.1282	0.1093	-1.1727
GDP	-8.8109	0.4080	21.5947
M1	-0.2162	0.1994	-1.0843
IND	-1.4975	0.0725	-20.6645
INF	0.0112	0.0188	0.5986
STI	0.0277	0.0952	0.2906
LTI	0.4933	0.1155	-4.2724
BCRUDE	-0.1333	0.0537	-2.4836
GOLD	0.3568	0.1010	3.5343
SIL	-0.7640	0.0695	-10.9993
PLAT	-0.5376	0.0802	-6.7048
PAL	0.1912	0.0338	5.6559
COPP	0.2938	0.0648	4.5377

Cointegrating Vector Equation

$$\beta'_1 = 1.000 - 0.1282 - 8.8109 - 0.2162 - 1.4975 + 0.1124 + 0.0277 + 0.4933 - 0.1333 + 0.3568 - 0.7640 - 0.5376 + 0.1912 + 0.2928$$

Cointegrating Relationship Equation

$$JSE_t = -24.5955 + 0.1282EX_t + 8.8109GDP_t + 0.2162M1_t + 1.4975IND_t - 0.1124INF_t - 0.0277STI_t - 0.4933LTI_t + 0.1333BCRUDE_t - 0.3568GOLD_t + 0.7640SIL_t + 0.5376PLAT_t - 0.1912PAL_t - 0.2928COPP_t$$

In Section 3.2 several hypotheses were set out with regard to each respective variables relationship with the JSE. The hypothesized relationship for each variable is indicated in Table 7 below in conjunction with the concluding results of each respective hypothesis. The significance, or lack thereof, of each respective variable's relationship with the JSE is indicated in Table 7 and is determined by the weak exogeneity test as per Section 4.6.

Table 7: Hypothesised Relationships and Results

Variable	Hypothesised Relationship with the JSE	Actual Relationship With the JSE	Result
EX*	Positive	Positive	Fail to Reject
GDP*	Positive	Positive	Fail to Reject
M1	Positive	Positive	Fail to Reject
IND*	Positive	Positive	Fail to Reject
INF	Negative	Negative	Fail to Reject
STI*	Negative	Negative	Fail to Reject
LTI	Negative	Negative	Fail to Reject
BCRUDE	Negative	Positive	Reject
GOLD*	Positive	Negative	Reject
SIL	Positive	Positive	Fail to Reject
PLAT	Positive	Positive	Fail to Reject
PAL	Positive	Negative	Reject
COPP	Negative	Negative	Fail to Reject

* denotes significance at the 5% level.

The normalized cointegration coefficients for the JSE as estimated from the VECM indicate the following relationships (which are discussed in conjunction with the hypotheses set out in Section 3.2 and the respective findings as set out in Table 7):

There is a positive relationship between the exchange rate and the JSE which indicates that a weaker rand results in stronger stock prices in South Africa (the exchange rate is included in this study as per American quote where the South African rand is the local currency and the US dollar is the foreign currency) and therefore one fails to reject the null hypothesis.

The relationship hypothesised between the JSE and GDP was set in accordance with the findings of Jefferis and Okhealam (2000) who found this relationship to be positive. One fails to reject this hypothesis in light of the findings. A positive relationships was hypothesised between the JSE and money supply as well as between the JSE and industrial production. These hypotheses were set in line with the findings of Abdullah and Hayworth (1993) and Chen et al. (1986) respectively – both of which fail to be rejected. The same conclusion is drawn with respect to the positive relationships hypothesised between the JSE and both silver and platinum. The same hypotheses were stipulated for the relationships between the JSE and gold and palladium respectively – both of which are subsequently rejected.

The variables hypothesised to have a negative relationship with the JSE include inflation, the short term interest rate, long term interest rate and Brent Crude oil. One fails to reject this hypothesis for inflation, the short term interest rate, and the long term interest rate – all of which are in line with the findings of Fama (1981) and Chen et al. (1986) respectively. Contrarily, the opposite is applicable with regard to Brent Crude oil which is positively related to the JSE, thus the null hypothesis is rejected. The finding of a positive relationship between the JSE and Brent Crude oil is in contradiction to the findings of Filis et al. (2011).

It is also noted that the intercept term of the JSE's cointegration relationship equation is negative.

4.6 WEAK EXOGENEITY

A weakly exogenous variables is one whose speed of adjustment coefficient (α) is insignificantly different from zero within the error correction model. This such variable will not adjust to deviations from its long-run equilibrium (Serfling & Miljkovic, 2011). Weak exogeneity was tested by imposing restrictions on the VECM - setting the respective speed of adjustment coefficients equal to zero and utilizing the LR test's chi-square in order to define significance.

Table 8: Weak Exogeneity Tests for the JSE

Variable	Cointegration Restriction		Chi-Square	p-value	Include / Exclude
EX*	B(1,1) = 1, A(2,1) = 0	$\alpha_{EX} = 0$	10.5499	0.0012	Include
GDP*	B(1,1) = 1, A(3,1) = 0	$\alpha_{GDP} = 0$	99.8650	0.0000	Include
M1	B(1,1) = 1, A(4,1) = 0	$\alpha_{M1} = 0$	0.4756	0.4904	Exclude
IND*	B(1,1) = 1, A(5,1) = 0	$\alpha_{IND} = 0$	7.7931	0.0052	Include
INF	B(1,1) = 1, A(6,1) = 0	$\alpha_{INF} = 0$	0.0191	0.8902	Exclude
STI*	B(1,1) = 1, A(7,1) = 0	$\alpha_{STI} = 0$	7.9046	0.0049	Include
LTI	B(1,1) = 1, A(8,1) = 0	$\alpha_{LTI} = 0$	0.3974	0.5285	Exclude
BCRUDE	B(1,1) = 1, A(9,1) = 0	$\alpha_{BCRUDE} = 0$	2.5242	0.1121	Exclude
GOLD*	B(1,1) = 1, A(10,1) = 0	$\alpha_{GOLD} = 0$	7.0276	0.0080	Include
SIL	B(1,1) = 1, A(11,1) = 0	$\alpha_{SIL} = 0$	1.1400	0.2856	Exclude
PLAT	B(1,1) = 1, A(12,1) = 0	$\alpha_{PLAT} = 0$	0.0266	0.8705	Exclude
PAL	B(1,1) = 1, A(13,1) = 0	$\alpha_{PAL} = 0$	0.0362	0.8490	Exclude
COPP	B(1,1) = 1, A(14,1) = 0	$\alpha_{COPP} = 0$	0.0091	0.9239	Exclude

* denotes significance at the 5% level.

The results provided in Table 8 can be explicitly interpreted as follows: Money supply, inflation, the long term interest rate, Brent Crude oil, silver, platinum, palladium and copper are weakly exogenous to the JSE at the five percent level of significance. Notably, in the case of a variable being weakly exogenous to the system that such variable is excluded from the model as it fails to adjust to deviations from the long run equilibrium. In light of this, the variables established to have significant long run equilibrium relationships with the JSE are the exchange rate, GDP, industrial production, short term interest rate and gold.

4.7 LONG RUN EQUILIBRIUM RELATIONSHIPS

In the tests for weakly exogenous variables to the system it was uncovered that the exchange rate, GDP, industrial production, the short term interest rate and gold are the variables which are in fact endogenous to the system. These significant variables are tested to deduce as to whether equivalent long run equilibrium relationships exist between these variables on the JSE. The hypothesis of each respective test and the corresponding results are illustrated in Table 9 below and interpreted thereafter.

Table 9: Long-Run Equilibrium on the JSE

Test	Long-Run Relationship	Hypothesis (H_0)	Alternative Hypothesis (H_1)	Chi-Square	p-value
1	Exchange Rate = GDP	B(1,1)=1, B(1,2)=B(1,3)	B(1,1)=1, B(1,2) ≠ B(1,3)	122.8699	0.0000
2	Exchange Rate = Industrial Production	B(1,1)=1, B(1,2)=B(1,4)	B(1,1)=1, B(1,2) ≠ B(1,4)	5.7863	0.0165
3*	**Exchange Rate = Short Term Interest Rate**	B(1,1)=1, B(1,2)=B(1,5)	B(1,1)=1, B(1,2) ≠ B(1,5)	2.5618	**0.1095**
4*	**Exchange Rate = Gold**	B(1,1)=1, B(1,2)=B(1,6)	B(1,1)=1, B(1,2) ≠ B(1,6)	0.4240	**0.5149**
5	GDP = Industrial Production	B(1,1)=1, B(1,3)=B(1,4)	B(1,1)=1, B(1,3) ≠ B(1,4)	122.4585	0.0000
6	GDP = Short Term Interest Rate	B(1,1)=1, B(1,3)=B(1,5)	B(1,1)=1, B(1,3) ≠ B(1,5)	123.4187	0.0000
7	GDP = Gold	B(1,1)=1, B(1,3)=B(1,6)	B(1,1)=1, B(1,3) ≠ B(1,6)	123.5621	0.0000
8*	**Industrial Production = Short Term Interest Rate**	B(1,1)=1, B(1,4)=B(1,5)	B(1,1)=1, B(1,4) ≠ B(1,5)	3.6711	**0.0554**
9	Industrial Production = Gold	B(1,1)=1, B(1,4)=B(1,6)	B(1,1)=1, B(1,4) ≠ B(1,6)	7.4655	0.0063
10*	**Short Term Interest Rate = Gold**	B(1,1)=1, B(1,5)=B(1,6)	B(1,1)=1, B(1,5) ≠ B(1,6)	1.0936	**0.2957**

*** denotes significance at the 5% level.**

The five significant endogenous variables result in ten different combinations of relationships between the variables as indicated in Table 9. A long run equilibrium relationship was hypothesised for each of the ten combinations respectively of which four significant equivalent long run equilibrium relationships were yielded at the five percent level of significance. The short term interest rate has an equivalent long run equilibrium relationship with the exchange rate, industrial production, and gold on the JSE respectively. Furthermore, the exchange rate also has an equivalent long run equilibrium relationship with gold on the JSE.

5 IN DEPTH ANALYSIS AND DISCUSSION

The empirical results of this study were interpreted on a high level in Section 4. This section will however provide an in depth analysis and discussion of the underlying findings and relative mechanics of the relationships between macroeconomic variables and metals prices with the JSE. First the relationship between stock prices and each of the five respective variables established to be significant will be discussed. Secondly insight into the relationships between the JSE and variables established to be insignificant will be analysed.

The empirical results of this study demonstrate that the JSE has a significant positive long run relationship with the exchange rate and industrial production, and a significant negative long run relationship with GDP, the short term interest rate and gold. The results also intimate that the JSE has a positive, long run relationship with money supply, the long term interest rate, Brent Crude oil, silver and platinum, as well as a negative, long run relationship with inflation, palladium and copper – these such relationships were however found to be insignificant.

5.1 EXCHANGE RATE

The exchange rate has a significant positive long run relationship with the JSE, thus indicating that the JSE is inversely related to the strength of the rand. Depreciation of the rand results in a relative price decrease of South African produced products in the international market which in turn results in an increase in exports and capital inflows. Furthermore, the South African equities market is comprised of a number of large capitalization rand hedge and rand leverage stocks for whom a weaker rand is favourable.

A positive long run relationship between the exchange rate and equity prices was identified by Jefferis and Okeahalam (2000) and is in unison with the findings of this study in a post-Apartheid South Africa. It is therefore evident that a weaker rand continues to be favourable for South African entities, for the most part, in the long term.

5.2 GDP

The JSE and GDP have a significant positive long run relationship which is in unison with economic theory and the majority of international literature. The correlation of the movements between stock prices and GDP are somewhat intuitive, and appear to be consistent in post-

Apartheid South Africa.

The intuitive, logical reasoning behind the direction of causality between the two variables is twofold. Modern portfolio theory is built on the assumption of market efficiency, which stipulates that a publicly traded security will fully reflect all available information at any given time (Fama, 1965). Under this assumption, stock prices incorporate information pertaining to future economic activity – this suggests that stock prices lead in a unidirectional causal relationship with GDP. Conversely, the unidirectional causality from GDP to stock prices can be debated in that a firm's future cash flows and performance is affected by GDP, therefore indicating that GDP leads stock prices. Although the causal relationships are not a primary focus of this study, analysis of the impulse response functions (see Section 4.2 and Section 9.3: Appendix C accordingly) indicate that there is minimal short run causality between the variables in either direction. This is unexpected given the strong positive long run relationship between the variables as indicated by the cointegrating vector equation.

A leading measure in determining the standing of an economy is GDP growth, which is commonly associated with an increase in the level of stock prices. Investor sentiment is believed to be optimistic in light of favourable GDP growth prospects as it incentivizes investors to allocate larger sums of capital to equities in the hopes of attaining superior returns. As can be intuitively deduced, the standing of the economy, investor sentiment and stock market should be one in the same with unilateral movement across the variables being evident. Notably, GDP has substantially the largest coefficient of the long run cointegrating vector equation, thus providing support for financial intuition.

The relationship is equivalent to that of Jefferis and Okeahalam (2000) who analysed the JSE from 1985 to 1995 and established a positive relationship between GDP and stock prices. The significance of GDP remains, as does the consistency of the relationship with stock prices in Apartheid South Africa.

5.3 INDUSTRIAL PRODUCTION

Subsequent to the establishment of the significant positive long run relationship between stock prices and GDP, the empirical results indicate the same relationship exists between stock prices and industrial production. Industrial production measures the level of real output of the industrial sector of the economy and includes mining, manufacture and utilities. Although industrial production contributes only a marginal proportion of total GDP, it is quantified as a separate measure owing to its sensitivity to interest rates and consumer demand.

Industrial production is a significant mechanism utilized to forecast future GDP and economic performance. The underlying intuition is in the domino effect whereby an increase in industrial production contributes positively to GDP and corporate profitability, therefore resulting in increased stock prices. The relationship between the short term interest rate and stock prices will be discussed in due course, but has been established to have a significant negative long run relationship with stock prices. Intuitively, a decrease in the interest rate will disincentivise investors from saving, which consequently increases consumer spending and/or demand and therefore industrial production, GDP and stock prices subsequently increase.

The hypothesis set out in this study was in line with the finding of Chen et al. (1986) who identified a positive relationship between industrial production and equity returns. The empirical results of this study reveal a significant positive long run relationship between industrial production and stock prices in post-Apartheid South Africa.

5.4 INTEREST RATES

As predominantly suggested in literature of the sort, the hypothesis set out in this study states that stock prices and the short term interest rate and long term interest rate have a negative relationship. The empirical results indicate that a significant, negative, long run relationship exists between stock prices and the short term interest rate in South Africa. Notably, the long term interest rate exhibits a negative relationship with stock prices – this finding is however insignificant.

The significant negative long run relationship between stock prices and the short term interest rate (and insignificant negative long run relationship with the long term interest rate) is in line with the vast volume of literature which delves into this relationship. The theoretical foundations are built on multiple facets of rationality. One view is that borrowing costs and profits are inversely related, where a reduction in borrowing costs increases profits and has a resultant "knock-on" effect to the stock price. A second theoretical view is that interest rates directly impact assets prices as it affects the applicable discount rates at which future cash flows are discounted. A decrease in the interest rate will increase the present value of future cash flows, thus increasing the stock price. Thirdly, interest rates affect equity prices via its effects on equity demand, whereby investors may alter their asset allocation decisions and modify the weighting of asset classes within their portfolios in order to attain superior returns. A reduction in the interest rate may result in investors replacing other financial assets (such as bonds) with equities causing equity demand and price to subsequently increase.

The fluctuation of the short term and long term interest rates are displayed graphically in Figure 3 followed by the correlation matrix in Table 10. It is observable that the short term interest rate (STI) and long term interest rate (LTI) have declined gradually over the period of 1995 to 2014 which coincides with the upward movement of the JSE over the same period. The movement between the two interest rates have a strong positive correlation as would be expected in the long term. However, considering the significance of the relationship between the JSE and the short and long term interest rates respectively (as determined by the LR test), it is interesting to note that the long term interest rate has a stronger negative correlation with the JSE than the short term interest rate.

Figure 3: Graph of the Short Term and Long Term Interest Rates (1995 to 2014)

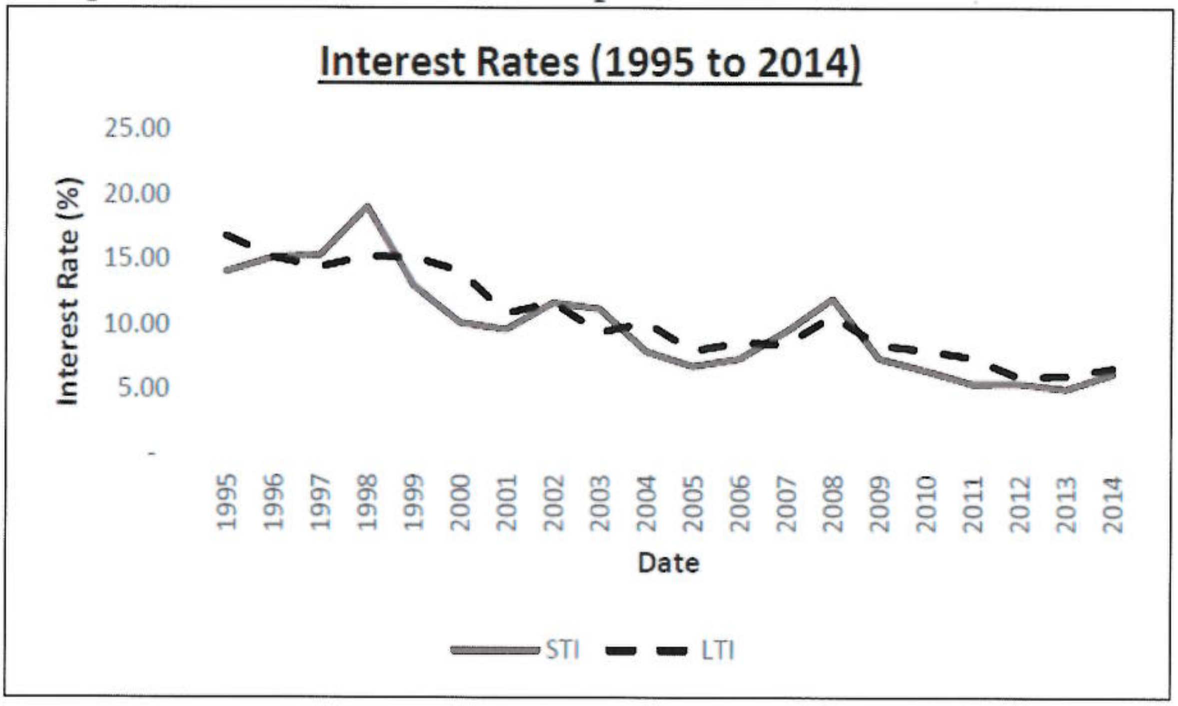


Table 10: Correlation Matrix

Variable	JSE	STI	LTI
JSE	1.0000	-0.7004	-0.8020
STI	-0.7004	1.0000	0.8910
LTI	-0.8020	0.8910	1.0000

Chen et al., (1986) provided empirical findings indicating that a negative relationship exists between interest rates and stock prices. The same result is highlighted in this study, thus establishing support in this regard. The impulse response function shows that short term fluctuation in stock prices is effectuated by the short term interest rate, which support Moolman and du Toit (2005) who studied the JSE over a period of 1978 to 2000. Furthermore, Van Rensburg (1999); Jefferis and Okeahalam (2000) found the long term interest rate to be significant and negatively related to equity prices respectively. The findings of this study with regard to the long term interest rate, despite being insignificant, is parallel to that identified in Apartheid South Africa.

5.5 GOLD

The empirical results of this study indicate that gold has a significant negative long run relationship with stock prices in South Africa. This finding is in contrast to the positive relationship set out in the hypothesis. Several schools of thought will be analysed so as to ascertain why this relationship presents itself.

Gold was identified by Labys and Pollak (1984); Radetzki (1989); Libicki (1996); Levin, Montagnoli and Wright (2006); Olivier (2011) to follow the same fundamentals of supply and demand in that a price increase will result in a decrease in demand and vice versa. The movement, and effect thereof, of a change in the gold price is also large affected by the exchange rate owing to the fact that the commodity is traded in US dollars. Evidence illustrates that a depreciation in the dollar will lower the price of gold to investors outside of the US and as a result the demand for gold will increase, hence an increase in the US dollar quoted gold price (Levin et al., 2006). One must however bear in mind, that in a South African context, a depreciation of the rand against the US dollar will result in an effective decrease in production costs and an increase in revenue resulting in an increase in profits and share price, with an appreciation of the rand having a contrasting result (Sorensen, 2011).

Although there has not been a constant depreciation of the rand from 1995 to 2014, there is a general trend indicating a depreciation of the rand over the time period. The same conclusion can be drawn with respect to the appreciation of the dollar quoted gold price. South African gold mining houses are rand leverage stocks and find favour in a depreciating rand and appreciating gold price, which would result in greater rand-based revenues, profits and stock prices. However, other considerations which may affect these such outcomes and negatively impact stock prices need to be addressed. Numerous prolonged labour strikes have taken place over the years which have resulted in a reduction of production levels and subsequent increased labour costs, consequently causing severe profit losses. Additionally, there have been echoed threats of nationalisation of the mining industry in South Africa causing investor unrest and subsequently impacting stock prices.

Gold has been identified, by investors, as a safe haven and pinpointed as an efficient hedge against political risk (Blose & Shieh, 1995) and might well be the determinant of the significant negative long run relationship between gold and stock prices in South Africa. South Africa's political transition post-Apartheid has been one predominantly featuring issues of corruption and public controversy, such as: cabinet members' alleged involvement in multimillion arms deals, and the embezzlement of paltry pension payments by state service officials to name but a couple (Hyslop, 2005). This ongoing systematic banter between the largely white opposition party, the Democratic Alliance, and the leading liberalization party, the African National Congress, continues to cause political risk, and unrest within South Africa. The volatility of the political situation in South Africa may drive investors between asset classes, gold and stocks, with the aim of hedging against political risk - therefore the resulting long run negative relationship between gold and stock prices.

Gold has also been identified as a significant tool utilized for its hedging abilities against the US dollar (Capie et al., 2005; Pule, 2013). Considering the volatility of the rand and the international gold market trading in US dollars, gold provides a cushion for South African investors against a weaker rand and/or a decrease in the gold price. The results display evidence of gold being a significant hedge against the US dollar. The negative relationship can be deduced graphically from Figure 4 and Figure 5 below.

Figure 4: Graph of the Gold Price in Rands (1995 to 2014)

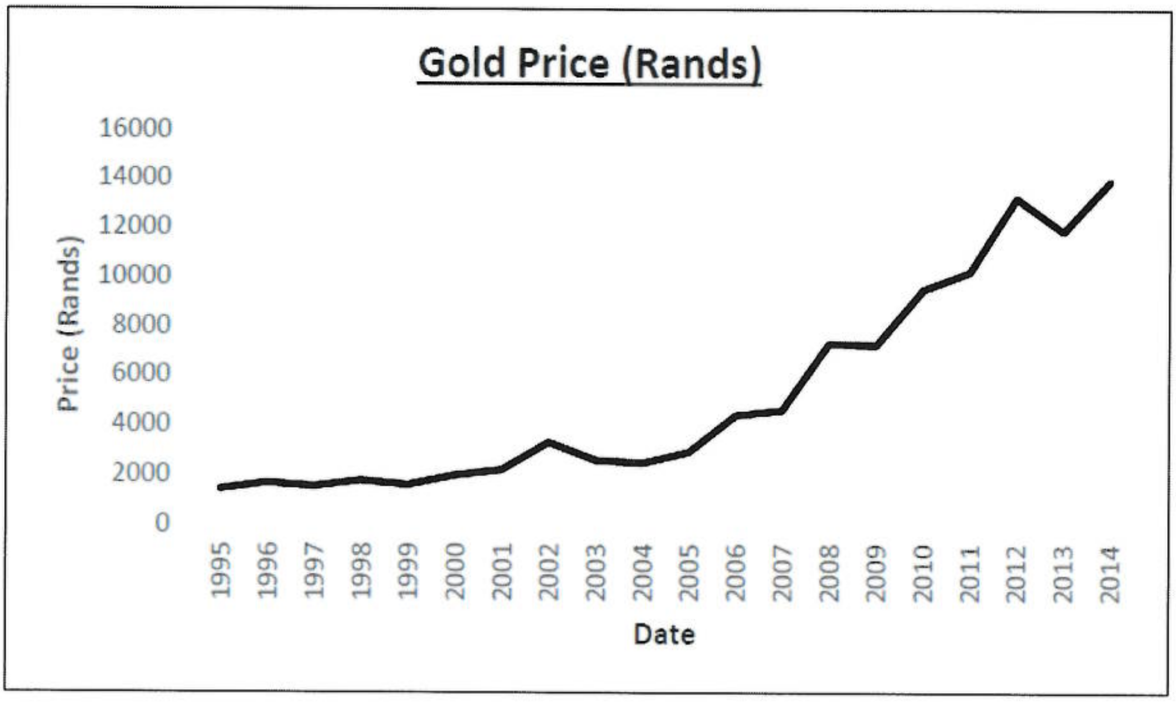
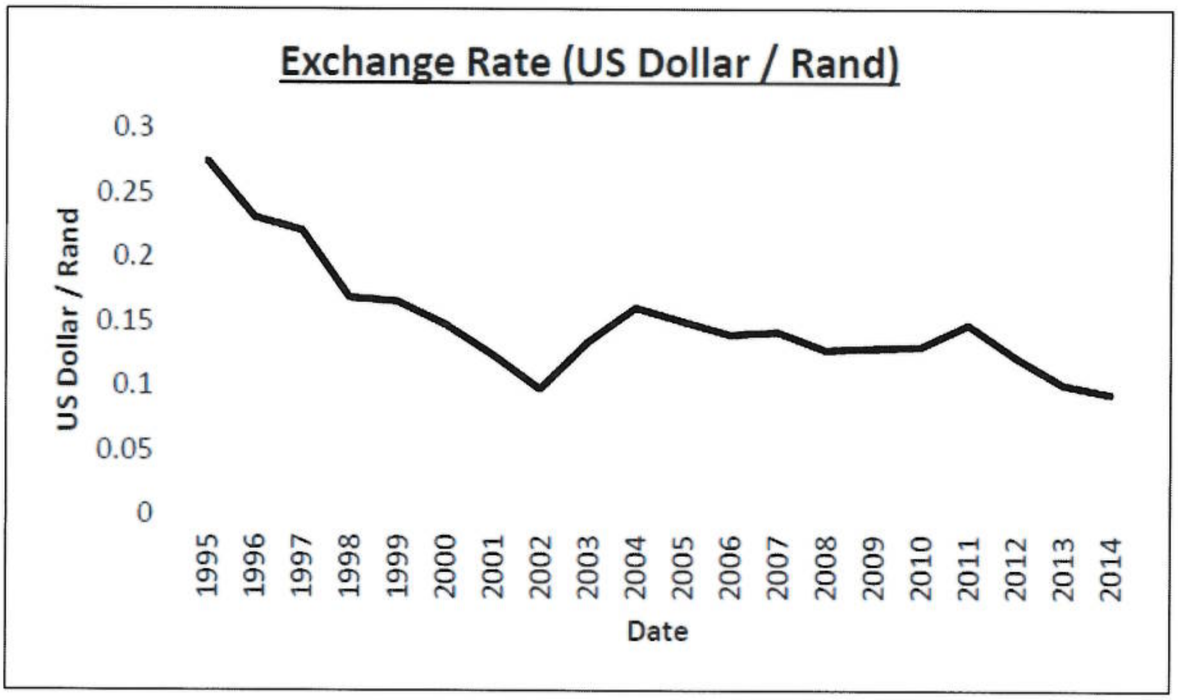


Figure 5: Graph of the US Dollar/Rand Exchange Rate (1995 to 2014)



5.6 MONEY SUPPLY

Although the positive long run relationship between money supply and stock prices is insignificant, the direction of this relationship proves to be consistent with financial analysts and literature for the most part. The price of a stock is calculated by discounting expected future cash flows by the applicable discount rate. Money supply has a significant relationship with the interest rate (which affects the discount rate), and therefore affects the present value of expected future cash flows.

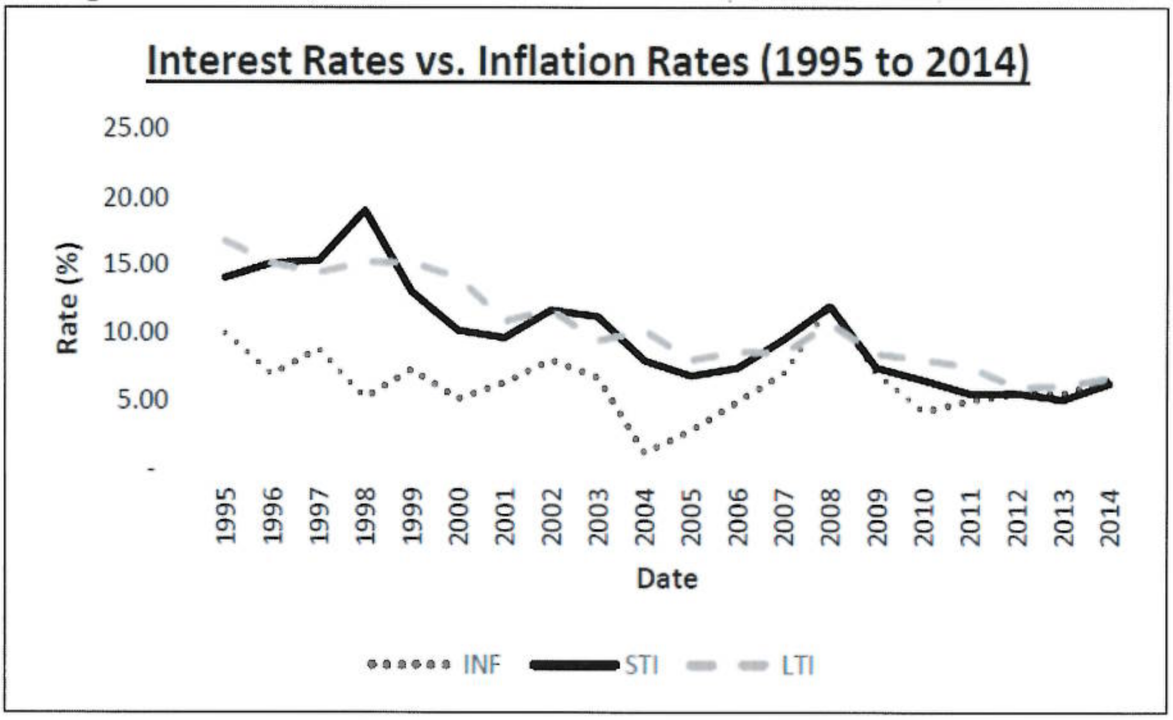
Differing theories exist as to how money supply affects stock prices. On the one hand, it is argued that money supply affects stock prices only if a change in money supply modifies investor perception of future monetary policy (Sellin, 2001). It is debated that a positive shock to money supply causes investors to perceive a contraction in future monetary policy, consequently resulting in a demand increase for bonds, therefore driving up the current interest rate. This subsequently pushes up the discount rate causing a reduction in the present value of expected future earnings. Furthermore, economic activity slows in the presence of increased interest rates which causes a further reduction in stock prices (Sellin, 2001). However, an opposing view shows that a positive shock to money supply implies that the demand for money is increasing which intimates that economic activity is on the rise. Greater economic activity is associated with inflated cash flows, and therefore higher stock prices. Additional support of a positive relationship between money supply and stock prices is provided by Bernanke and Kuttner (2005) who explain that stock price is a function of monetary value and the risk associated with holding the stock. The attractiveness of a stock is positively related to its monetary value, whereas it is inversely related to its underlying riskiness. The authors believe that an expansionary monetary policy decreases the risk premium (interest rate) required to compensate investors for holding a risky asset and further suggest an expansion of economic activity, thus increasing the probability of future profits. The lower associated risk is partnered with a smaller expected risk premium, therefore making the stocks more attractive and driving up the stock prices (Bernanke & Kuttner, 2005).

The empirical findings indicate the presence of a significant negative long run relationship between interest rates and stock prices as illustrated in Figure 3. This decrease in interest rates is associated with greater money supply and therefore growth in economic activity. Increased economic activity has a positive effect on the GDP which translates into higher stock prices as is evidenced in this study.

5.7 INFLATION

Inflation proved to be relatively volatile over the period of 1995 to 2014 as can be deduced from Figure 6 below. However, the long run relationship between stock prices and inflation was established to be insignificantly negative. Geske and Roll (1983); Chen et al. (1986) are among the literature of evidence which found this relationship. A negative relationship between inflation and stock prices is apparent, according to financial theory, owing to the relationship between inflation and the nominal interest rate (as illustrated in Figure 6).

Figure 6: Graph of Interest Rates vs. Inflation Rate (1995 to 2014)



The linear relationship between the interest rate and inflation rate is determined by the following equation:

$$Nominal\ Interest\ Rate = [(1 + Real\ Interest\ Rate) \times (1 + Inflation\ Rate)] - 1$$

This linear relationship enables the translation of the negative relationship between stock prices and inflation. The inflation rate directly impacts the nominal interest rate which is utilized to discount expected future cash flows to ascertain the stock price. The decrease of inflation and the nominal interest rates over the past twenty years is partnered with the increase of the JSE which supports the findings of a negative relationship between inflation and stock prices.

5.8 BRENT CRUDE OIL

The empirical findings indicate that the long run relationship between Brent Crude oil and stock prices is positive. Albeit insignificant, this relationship is in contradiction to the hypothesis set out and requires deeper analysis. From a microeconomic perspective, a negative relationship between Brent Crude oil and stock prices can be understood in that an increase in the oil price drives up the production costs of companies for whom oil is a direct or indirect constituent in production. Al-Fayoumi (2009) explains that if a firm is unable to relay this increased cost to customers in totality then the firm's profits will be adversely affected, therefore hindering the level of dividend payouts and consequently depress stock prices. Furthermore, non-oil producing countries endure price increases and are confronted with greater risk exposure and uncertainty surrounding oil price volatility which adversely affects stock prices. It is also noted that ascending oil prices are associated with inflationary pressures which often coerce policy makers into raising interest rates in order to control inflation (Sahu, Bandopadhyay & Mondal, 2014). Rising interest rates, as distinguished in Section 6.4, directly impact discount rates which have an inverse relationship with stock prices.

A positive relationship is expected to exist between Brent crude oil and stock prices in oil-exporting countries. This relationship can be explained by the increase in demand of basic materials, such as crude oil, during economic booms and/or recoveries. Two economic recessions fall within the timeline of this study, namely: the Asian crisis from 1997 to 1999 and the Great Recession from 2007 to 2009. Prior to which, and succeeding thereafter, was a boom and a recovery respectively during which demand of crude oil would increase and favourably affect stock prices. Higher oil prices also embody an immediate transfer of wealth from net oil importers to net oil exporters. Provided oil exporting governments channel the increased income into local goods and services, economic activity levels will rise and ameliorate relative stock market returns (Sahu et al., 2014)

South Africa is a net importer of oil and local companies should therefore be adversely affected by surges in the price of Brent Crude oil, this however was not established to be the case. A first possible explanation is that companies who are affected by rising oil prices, owing to the direct and/or indirect impact on production costs, are able to transfer increased production costs to the final consumer in totality. Transferring the increased production costs to the final consumer allows firms to maintain profit levels and stock prices. Secondly, globalisation has resulted in greater integration and co-movement across international markets. Goetzmann, Li and Roewenhorst (2005) argue that integration and co-movements of asset returns are positively related. South African stock prices are therefore potentially correlated with those of oil exporting countries whose stock prices are positively related to increases in the oil price.

5.9 SILVER

Although insignificant, the positive relationship between silver and stock prices established from the empirical results will be dissected. A weaker rand and rising silver price has a positive impact on stock prices of silver producing companies, as is explained to be the case for gold producing companies in South Africa. Silver however is not as prominently produced in South Africa as gold and/or platinum (but rather as a by-product by these such companies) and therefore fluctuations in the silver price do not cause as severe an impact on stock prices as fluctuations in the gold and/or platinum price may. All else equal, an increase in the silver price and/or a depreciation of the rand against the US dollar positively affects the profits of silver producing companies, therefore having a favourable impact on stock prices – hence the positive long run relationship between silver and stock prices.

5.10 PLATINUM

Platinum has a positive long run relationship with stock prices as expected, however this relationship is interestingly insignificant. South Africa is substantially the largest producer of platinum in the world, and a number of the leading platinum mining houses are listed on the JSE. The effect of changes in the platinum price is therefore expected to have a significant effect on the profit levels of platinum producers in South Africa, and subsequently on their relative share prices. Illustrated in Figure 7 is the platinum price (in dollars) for the period of 1995 through to 2014 from which it is clearly observable that the platinum price has increased considerably. Partnered with the dollar price increase of platinum is the substantial depreciation of the rand over the same period (as illustrated in Figure 5). The resulting rand price level for platinum is illustrated in Figure 8 below, from which a sizeable increase in the platinum price can be observed. As with gold, a reduction in the strength of the rand results in greater rand revenues and lower rand production costs (provided the relative production costs remain unchanged) for platinum producers, owing to the international platinum market trading in US dollars. Consequently, the increased spread between revenue and the relative production costs as a result of the weakening rand translates into larger profits for South African mining houses and therefore higher stock prices.

Figure 7: Graph of the Platinum Price in Dollars (1995 to 2014)

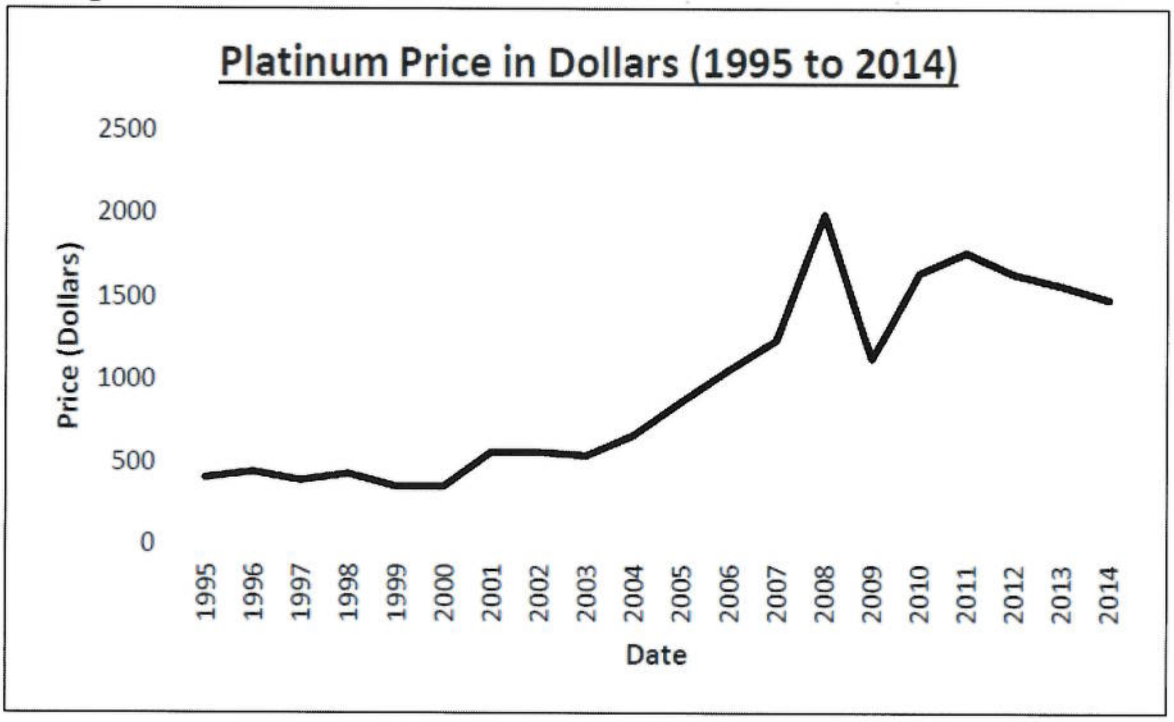
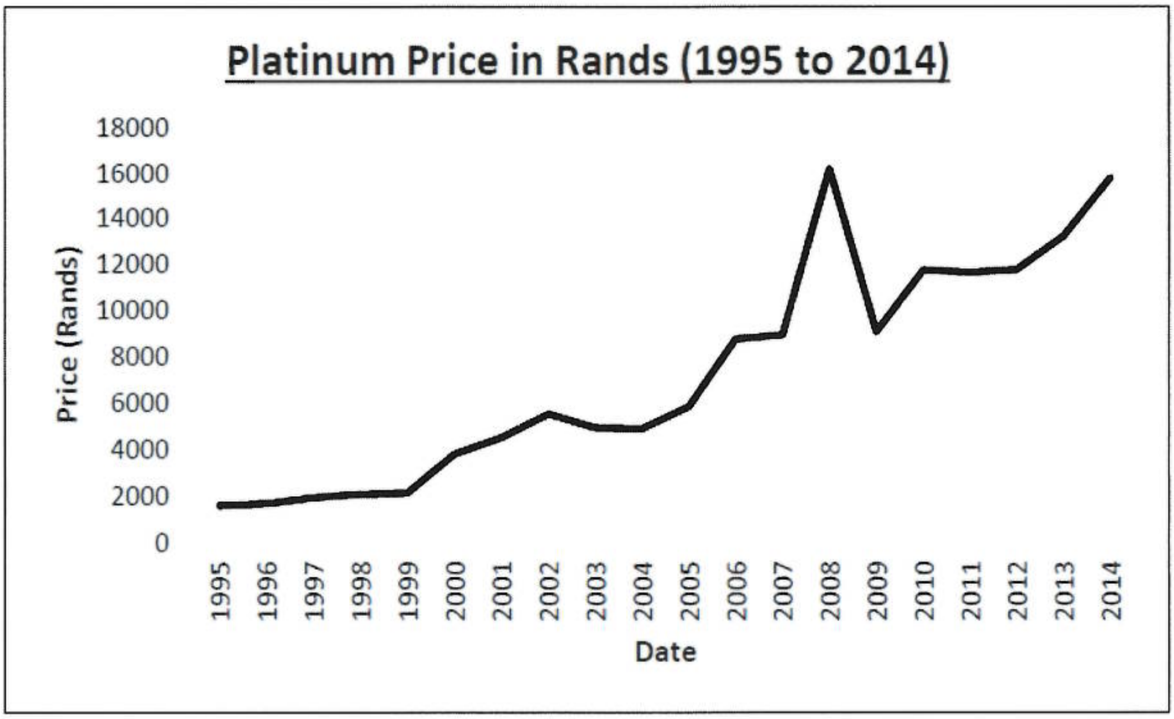


Figure 8: Graph of the Platinum Price in Rands (1995 to 2014)



It is noted that there have been a number of labour strikes at major platinum mines in South Africa, the most prominent being that at Lonmin (commonly referred to as the Marikana strike) in 2012 and the five month strike across Anglo American Platinum, Impala Platinum and Lonmin in 2014. These strikes have undeniably had severe negative effects on production levels and profits within the platinum mining industry in South Africa. However, for the most part, the weakening rand and rising platinum price is favourable for local platinum producers and can explain the positive relationship between the platinum price and the JSE.

5.11 PALLADIUM

The palladium price was hypothesized to have a positive long run relationship with stock prices. However, this relationship did not materialize as per the empirical findings. Interestingly, platinum and palladium have a correlation of 0.7 which would suggest that the two metals would have a similar relationship with stock prices which proves not to be the case. This relationship is however insignificant, but requires further investigation.

5.12 COPPER

South Africa are the second largest producer of copper in Africa, but still however import a noteworthy volume of copper from Zambia. Owing to this substantial level of import, South

African corporates are susceptible to price changes. A price increase, as experienced from 1995 to 2014, has an adverse effect on corporate profits which transfers into reduced stock prices. The empirical findings fail to reject the negative long run relationship hypothesised between copper and stock prices.

6 CONCLUSION

There is a large pool of literature which explores the relationship between macroeconomic variables and stock prices in international markets. It is however apparent that research of this sort has not been implemented to the same extent in South Africa. More so, there is a great shortage of South African studies which have utilized the VECM which is identified as the more accurate and appropriate methodology in the determination of cointegrating relationships between variables within a system. The Johansen (1991) cointegration methodology was implemented in an empirical analysis of the long run equilibrium relationships between macroeconomic factors, metals and the JSE over the period of June 1995 to May 2014. This study provides insight, and entices future research of this sort in a post-Apartheid South Africa.

The impulse response functions and variance decomposition afford vision into the short run fluctuations of the JSE. It is established that the JSE responds, in the short run, to one time standard deviation shocks to the exchange rate, money supply, inflation, short term interest rate, long term interest rate, and silver. The responsiveness of the JSE to one time standard deviation innovations to macroeconomic variables and metals is not persistent, nor do these fluctuations account for a significant proportion of total short run movement of the JSE. It is identified that the most dominant source of variation of the JSE is the prior quarter performance of the JSE itself, which is in unison with Chinzara and Aziakpono (2009) who indicate that the majority of forecast error variance within a series is explicated owing to its own variance.

The empirical findings of the cointegration analysis and VECM are in accordance with fundamental literature of its sort. Utilizing quarterly time series data, five factors are identified to elucidate the pricing process of the JSE. Furthermore, these factors are established to have a long run relationship with stock prices in South Africa at a five percent confidence level. The exchange rate, GDP, and industrial production are established to have a positive relationship with the JSE, whereas the short term interest rate, and gold have a negative relationship with the JSE. These findings are in conformity with financial theory and literature of the sort. It is interesting to note that the prevalence of gold mining in South Africa has not materialized into a positive long run relationship between gold and the JSE. However, the negative relationship contributes to the existing consensus of gold being a currency and inflation hedge mechanism.

Jefferis and Okeahalam (2000) analysed the relationship between numerous macroeconomic factors and the JSE, using quarterly data, over a period of 1985 to 1995. The authors adopted the cointegration methodology and identified that in the long run stock prices are positively related to the exchange rate and GDP and negatively related to the long term interest rate. The empirical findings of the Jefferis and Okeahalam (2000) paper, which was conducted on an Apartheid affected South African stock market, are directly comparable to the findings of this study. It is apparent that the quarterly measure of the exchange rate and GDP remain significantly cointegrated with the JSE post-Apartheid. The long run susceptibility of the JSE to the long term interest rate is no longer evident, however this susceptibility has transferred to the short term interest rate. Importantly, industrial production and gold have also been identified as significant factors in post-Apartheid South Africa.

It has been suggested that long run cointegrating relationships exist between stock prices and particular macroeconomic variables (Chen et al., 1986; Fama, 1981; 1990; Ferson & Harvey, 1991). The empirical findings of this study afford evidence in favour of macroeconomic factors having cointegration with stock prices, which is in line with this proposition. The exchange rate, GDP, industrial production, short term interest rate, and gold have been pinpointed as priced risk factors in a post-Apartheid South African stock market. The identification of multiple factors rejects the legitimacy of the CAPM in support of the multifactor APT.

7 RECOMMENDATIONS

In light of the empirical findings indicated above, the following recommendations are put forth for future research: Firstly, the relationships, and significance thereof, between the JSE and global economic factors should be analysed in order to determine the prevalence of global market integration between South Africa and other international markets. Secondly, the effects of qualitative factors may prove to be of significance, and therefore researchers may seek to shed light on the impact of the following: legislation amendments, political events, economic contract obligations, as well as labour disputes and power shortages. Legislation amendments may include changes in tax law and changes in land ownership rights. Amendments of these such laws are likely to affect both local and foreign investors' sentiment. Investor sentiment is also expected to be affected by political events and the potential of local industry nationalisation. Economic contract obligations such as the $50 billion nuclear deal between South Africa and Russia is a potential area of relevance. The effect of the current power crisis is of concern to local and foreign investors and may be an applicable avenue of research. Lastly, the prominence of the relationship between the JSE and labour strikes should be investigated as these strikes largely affect production levels (and GDP) and impact production costs via the resultant incremental increased labour costs incurred, consequently impacting stock prices.

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9 APPENDICES

9.1 APPENDIX A: DEFINITIONS

Table 11: Definition of Key Terms

Term	Definition
Impulse Response Functions (IRF)	Enable the determination of structural innovation or shocks and the effect which these have on a variable within the estimated system. This involves the tracing of the marginal effect of a shock in one variable and its effect on another variable.
Johannesburg Stock Exchange (JSE)	The South African stock market, where securities can be traded freely under a regulated procedure.
Variance decompositions	Is the decomposition of the proportion to which each variable's variation is determined by a shock or innovation experienced by another variable within the estimated VAR, thus allowing identification of the effect of an exogenous shock to the development of a variable in the system (Stock and Watson, 2001).
Vector Autoregression (VAR)	A statistical model used to capture the linear interdependencies among multivariate time series, which utilize both lagged independent and dependent variables in explaining time-series data.
Vector Error Correction Model (VECM)	Allows for the estimation of long term relationships in non-stationary data based on cointegration between the variables in a VAR.

Table 12: Time series Transformations

Time-Series Transformations	
Δ ALSI = ln($ALSI_t$ / $ALSI_{t-1}$)	Quarterly return on the JSE ALSI
Δ EX = ln(EX_t / EX_{t-1})	Quarterly change in the exchange rate
Δ GDP = ln(GDP_t / GDP_{t-1})	Quarterly change in GDP
Δ M1 = ln($M1_t$ / $M1_{t-1}$)	Quarterly change in money supply
Δ IND = Ln(IND_t / IND_{t-1})	Quarterly change in industrial production
Δ INF = ln(INF_t / INF_{t-1})	Quarterly change in the inflation rate
Δ STI =ln(STI_t / STI_{t-1})	Quarterly change in short-term interest rates
Δ LTI = ln(LTI_t / LTI_{t-1})	Quarterly change in long-term interest rates
Δ BCRUDE = ln($BCRUDE_t$ / $BCRUDE_{t-1}$)	Quarterly change in the Brent Crude oil price
Δ GOLD = ln($GOLD_t$ / $GOLD_{t-1}$)	Quarterly change in the gold price (Rands)
Δ SIL = ln(SIL_t / SIL_{t-1})	Quarterly change the silver price (Rands)
Δ PLAT = ln($PLAT_t$ / $PLAT_{t-1}$)	Quarterly change in the platinum price (Rands)
Δ PAL = ln(PAL_t / PAL_{t-1})	Quarterly change in the palladium price (Rands)
Δ COPP = ln($COPP_t$ / $COPP_{t-1}$)	Quarterly change in the copper price (Rands)

9.2 APPENDIX B: UNIT ROOT TESTS

9.2.1 AUGMENTED DICKEY-FULLER TESTS

Table 13: Augmented Dickey-Fuller Test on the JSE (Level)

Null Hypothesis: ALSI has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.023056	0.9999
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 14: Augmented Dickey-Fuller Test on the JSE (Differenced)

Null Hypothesis: EX has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.76054	0.0689
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 15: Augmented Dickey-Fuller Test on the Exchange Rate (Level)

Null Hypothesis: EX has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.76054	0.0689
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 16: Augmented Dickey-Fuller Test on the Exchange Rate (Differenced)

Null Hypothesis: D(EX) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.68547	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 17: Augmented Dickey-Fuller Test on GDP (Level)

Null Hypothesis: GDP has a unit root

Exogenous: Constant

Lag Length: 5 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.25838	0.9250
Test critical values	1% level	-3.52562	
	5% level	-2.90295	
	10% level	-2.5889	

Table 18: Augmented Dickey-Fuller Test on GDP (Differenced)

Null Hypothesis: D(GDP) has a unit root

Exogenous: Constant

Lag Length: 4 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.92064	0.0438
Test critical values	1% level	-3.52562	
	5% level	-2.90295	
	10% level	-2.5889	

Table 19: Augmented Dickey-Fuller Test on Money Supply (Level)

Null Hypothesis : M1 has a unit root

Exogenous : Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.618163	1.0000
Test critical values .	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 20: Augmented Dickey-Fuller Test on Money Supply (Differenced)

Null Hypothesis: D(M1) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.31822	0.0000
Test critical values	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 21: Augmented Dickey-Fuller Test on Industrial Production (Level)

Null Hypothesis : IND has a unit root

Exogenous : Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.155078	0.9976
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 22: Augmented Dickey-Fuller Test on Industrial Production (Differenced)

Null Hypothesis: D(IND) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.98805	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 23: Augmented Dickey-Fuller Test on Inflation (Level)

Null Hypothesis: INF has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.96244	0.0027
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 24: Augmented Dickey-Fuller Test on Inflation (Differenced)

Null Hypothesis: D(INF) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.6354	0.0000
Test critical values:	1% level	-3.52423	
	5% level	-2.90236	
	10% level	-2.58859	

Table 25: Augmented Dickey-Fuller Test on the Short Term Interest Rate (Level)

Null Hypothesis: STI has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.80739	0.3743
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 26: Augmented Dickey-Fuller Test on the Short Term Interest Rate (Differenced)

Null Hypothesis: D(STI) has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.77985	0.0000
Test critical values	1% level	-3.52158	
	5% level	-2.90122	
	10% level	-2.58798	

Table 27: Augmented Dickey-Fuller Test on the Long Term Interest Rate (Level)

Null Hypothesis: LTI has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.00496	0.7477
Test critical values:	1% level	-3.52158	
	5% level	-2.90122	
	10% level	-2.58798	

Table 28: Augmented Dickey-Fuller Test on the Long Term Interest Rate (Differenced)

Null Hypothesis: D(LTI) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.00863	0.0000
Test critical values	1% level	-3.52158	
	5% level	-2.90122	
	10% level	-2.58798	

Table 29: Augmented Dickey-Fuller Test on Brent Crude oil (Level)

Null Hypothesis: BCRUDE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.28239	0.9218
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 30: Augmented Dickey-Fuller Test on Brent Crude oil (Differenced)

Null Hypothesis: D(BCRUDE) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.80478	0.0000
Test critical values	1% level	-3.52158	
	5% level	-2.90122	
	10% level	-2.58798	

Table 31: Augmented Dickey-Fuller Test on Gold (Level)

Null Hypothesis: GOLD has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.074223	0.9970
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 32: Augmented Dickey-Fuller Test on Gold (Differenced)

Null Hypothesis: D(GOLD) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.4578	0.0001
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 33: Augmented Dickey-Fuller Test on Silver (Level)

Null Hypothesis: SIL has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.22898	0.9292
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 34: Augmented Dickey-Fuller Test on Silver (Differenced)

Null Hypothesis: D(SIL) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic- based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.24	0.0001
Test critical values	1% level	-3.52031	
	5% level	-2.90087	
	10% level	-2.58769	

Table 35: Augmented Dickey-Fuller Test on Platinum (Level)

Null Hypothesis: PLAT has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic- based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.21787	0.9307
Test critical values	1% level	-3.52158	
	5% level	-2.90122	
	10% level	-2.58798	

Table 36: Augmented Dickey-Fuller Test on Platinum (Differenced)

Null Hypothesis: D(PLAT) has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic- based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.43248	0.0000
Test critical values:	1% level	-3.52158	
	5% level	-2.90122	
	10% level	-2.58798	

Table 37: Augmented Dickey-Fuller Test on Palladium (Level)

Null Hypothesis: PALL has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.21826	0.9307
Test critical values:	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 38: Augmented Dickey-Fuller Test on Palladium (Differenced)

Null Hypothesis: D(PALL) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.43062	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 39: Augmented Dickey-Fuller Test on Copper (Level)

Null Hypothesis: COPP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.2404	0.6530
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 40: Augmented Dickey-Fuller Test on Copper (Differenced)

Null Hypothesis: D(COPP) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.71205	0.0000
Test critical values:	1% level	-3.52158	
	5% level	-2.90122	
	10% level	-2.58798	

9.2.2 PHILLIPS-PERRON TESTS

Table 41: Phillips-Perron Test on the JSE (Level)

Null Hypothesis: ALSI has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		1.750948	0.9997
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 42: Phillips-Perron Test on the JSE (Differenced)

Null Hypothesis: D(ALSI) has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.639	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 43: Phillips-Perron Test on the Exchange Rate (Level)

Null Hypothesis: EX has a unit root
Exogenous: Constant

Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.7279	0.0740
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 44: Phillips-Perron Test on the Exchange Rate (Differenced)

Null Hypothesis: D(EX) has a unit root
Exogenous: Constant

Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-7.70637	0.0000
Test critical values	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 45: Phillips-Perron Test on GDP (Level)

Null Hypothesis: GDP has a unit root
Exogenous: Constant
Bandwidth: 13 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.22617	0.9297
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 46: Phillips-Perron Test on GDP (Differenced)

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-17.6831	0.0001
Test critical values	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 47: Phillips-Perron Test on Money Supply (Level)

Null Hypothesis: M1 has a unit root
Exogenous: Constant

Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		2.972518	1.0000
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 48: Phillips-Perron Test on Money Supply (Differenced)

Null Hypothesis: D(M1) has a unit root
Exogenous: Constant

Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-9.40928	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 49: Phillips-Perron Test on Industrial Production (Level)

Null Hypothesis: IND has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		1.143077	0.9976
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 50: Phillips-Perron Test on Industrial Production (Differenced)

Null Hypothesis: D(IND) has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.00608	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 51: Phillips-Perron Test on Inflation (Level)

Null Hypothesis: INF has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-3.16172	0.0263
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 52: Phillips-Perron Test on Inflation (Differenced)

Null Hypothesis: D(INF) has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.06717	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 53: Phillips-Perron Test on the Short Term Interest Rate (Level)

Null Hypothesis: STI has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.60697	0.4741
Test critical values:	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 54: Phillips-Perron Test on the Short Term Interest Rate (Differenced)

Null Hypothesis: D(STI) has a unit root
Exogenous: Constant
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.58474	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 55: Phillips-Perron Test on the Long Term Interest Rate (Level)

Null Hypothesis: LTI has a unit root
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.6282	0.4634
Test critical values:	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 56: Phillips-Perron Test on the Long Term Interest Rate (Differenced)

Null Hypothesis: D(LTI) has a unit root
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-9.22317	0.0000
Test critical values	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 57: Phillips-Perron Test on Brent Crude Oil (Level)

Null Hypothesis: BCRUDE has a unit root
Exogenous: Constant

Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		0.623021	0.9895
Test critical values:	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 58: Phillips-Perron Test on Brent Crude Oil (Differenced)

Null Hypothesis: D(BCRUDE) has a unit root
Exogenous: Constant
Bandwidth: 22 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-9.99597	0.0000
Test critical values	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 59: Phillips-Perron Test on Gold (Level)

Null Hypothesis: GOLD has a unit root
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		1.152467	0.9978
Test critical values	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 60: Phillips-Perron Test on Gold (Differenced)

Null Hypothesis: D(GOLD) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-11.3104	0.0001
Test critical values	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 61: Phillips-Perron Test on Silver (Level)

Null Hypothesis: SIL has a unit root
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.36788	0.9085
Test critical values:	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 62: Phillips-Perron Test on Silver (Differenced)

Null Hypothesis: D(SIL) has a unit root
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-11.143	0.0001
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 63: Phillips-Perron Test on Platinum (Level)

Null Hypothesis: PLAT has a unit root
Exogenous: Constant
Bandwidth: 18 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.13405	0.9412
Test critical values:	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 64: Phillips-Perron Test on Platinum (Differenced)

Null Hypothesis: D(PLAT) has a unit root

Exogenous: Constant

Bandwidth: 30 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-17.2607	0.0001
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 65: Phillips-Perron Test on Palladium (Level)

Null Hypothesis: PALL has a unit root

Exogenous: Constant

Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.21826	0.9307
Test critical values:	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 66: Phillips-Perron Test on Palladium (Differenced)

Null Hypothesis: D(PALL) has a unit root

Exogenous: Constant

Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.43055	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

Table 67: Phillips-Perron Test on Copper (Level)

Null Hypothesis: COPP has a unit root

Exogenous: Constant

Bandwidth: 8 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.11607	0.7057
Test critical values:	1% level	-3.51905	
	5% level	-2.90014	
	10% level	-2.58741	

Table 68: Phillips-Perron Test on Copper (Differenced)

Null Hypothesis: D(COPP) has a unit root

Exogenous: Constant

Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.24641	0.0000
Test critical values:	1% level	-3.52031	
	5% level	-2.90067	
	10% level	-2.58769	

9.3 APPENDIX C: IMPULSE RESPONSE FUNCTIONS

Figure 9: Impulse Response Function of the Exchange Rate

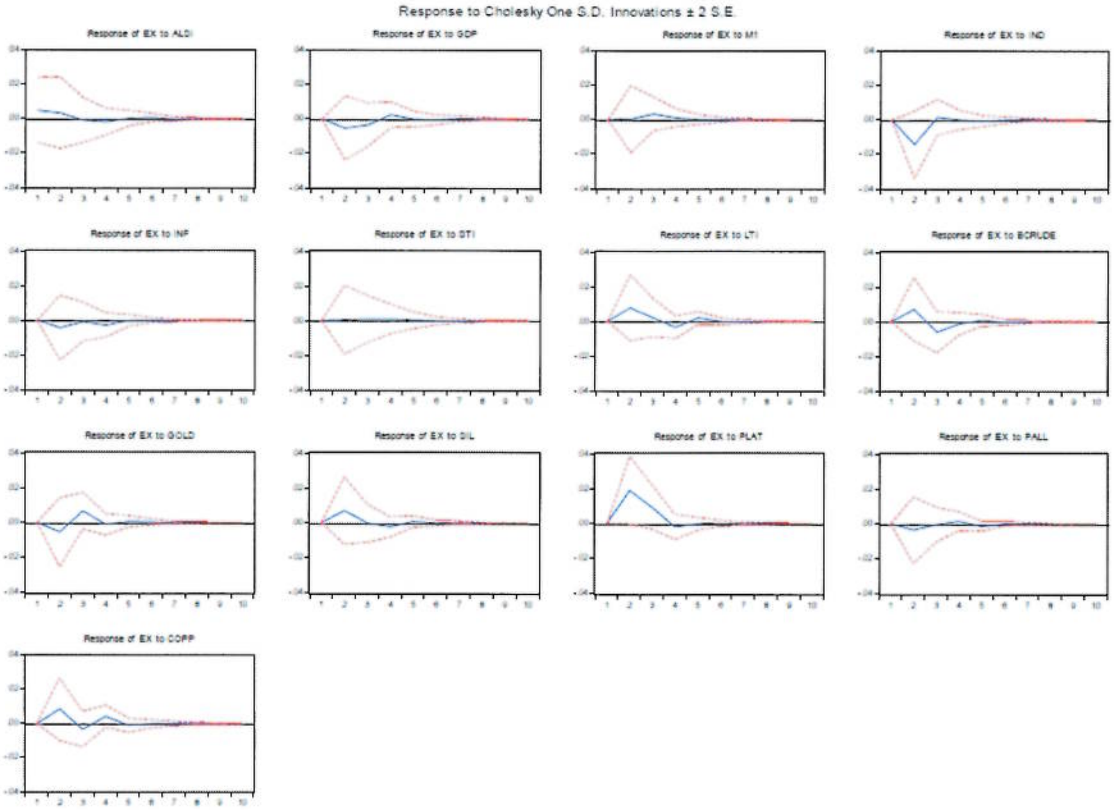


Figure 10: Impulse Response Function of GDP

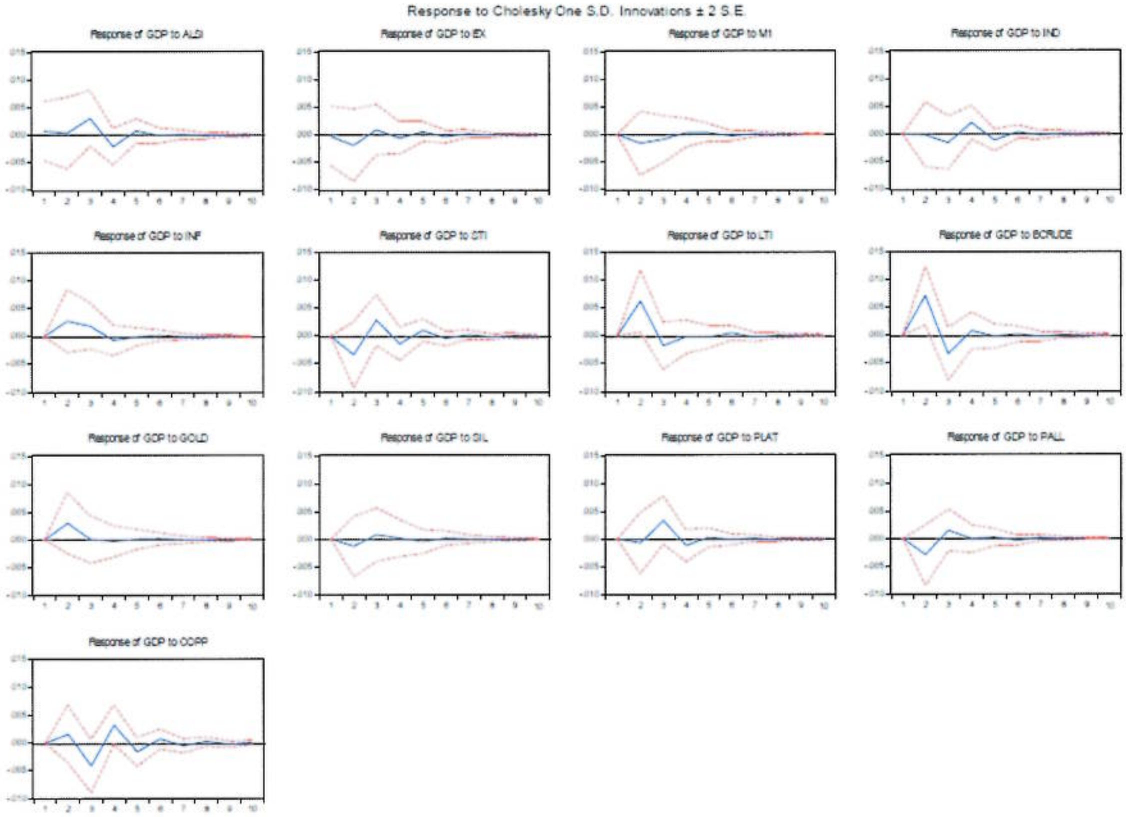


Figure 11: Impulse Response Function of Money Supply

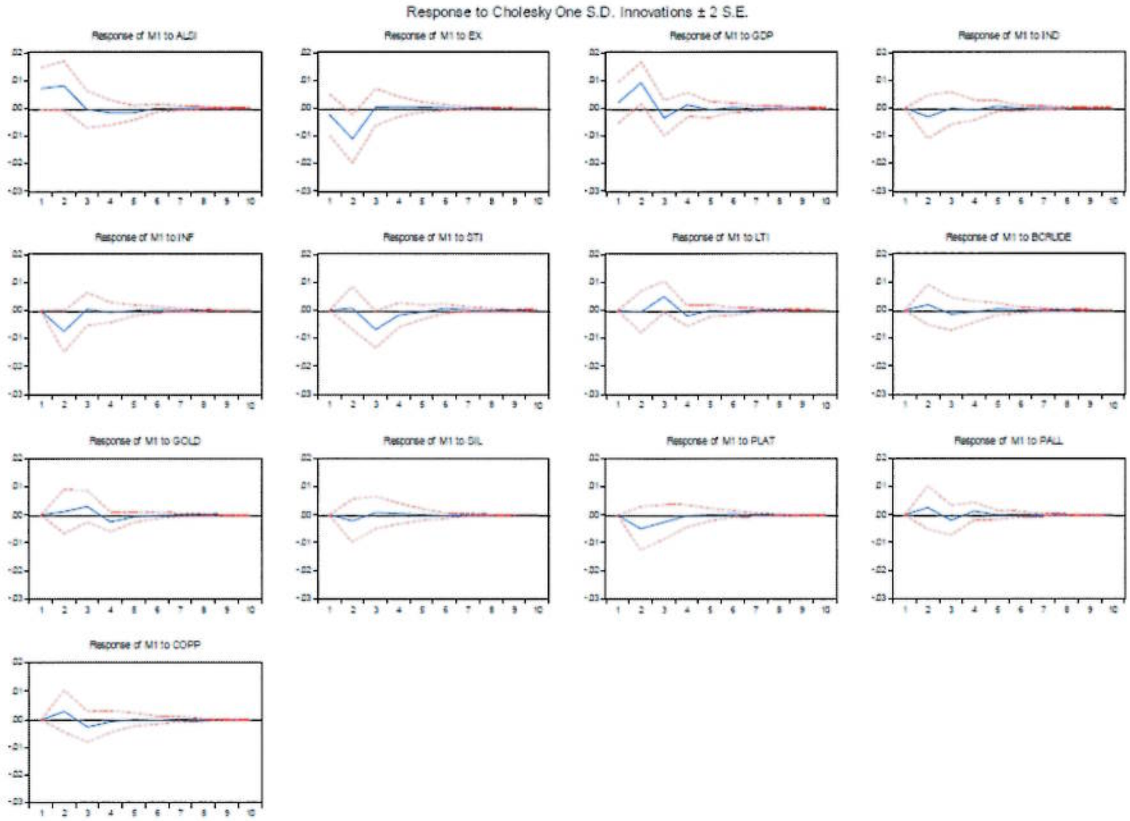


Figure 12: Impulse Response Function of Industrial Production

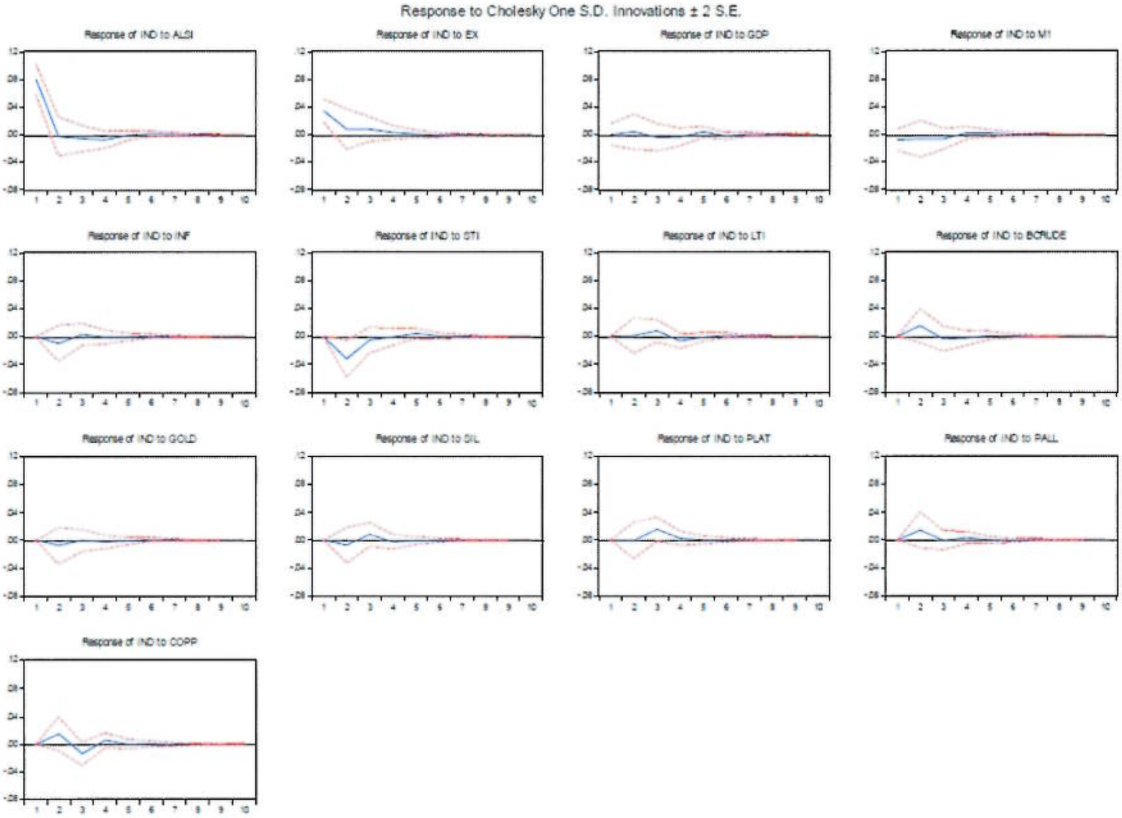


Figure 13: Impulse Response Function of Inflation

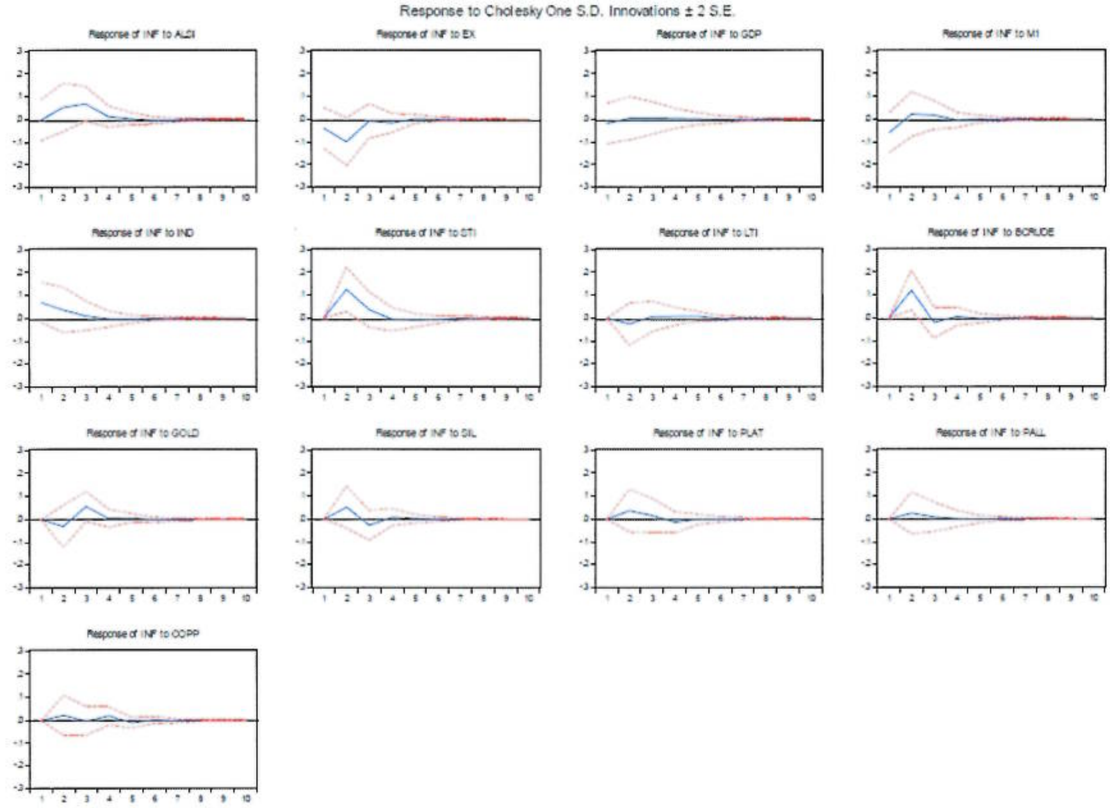


Figure 14: Impulse Response Function of the Short Term Interest Rate

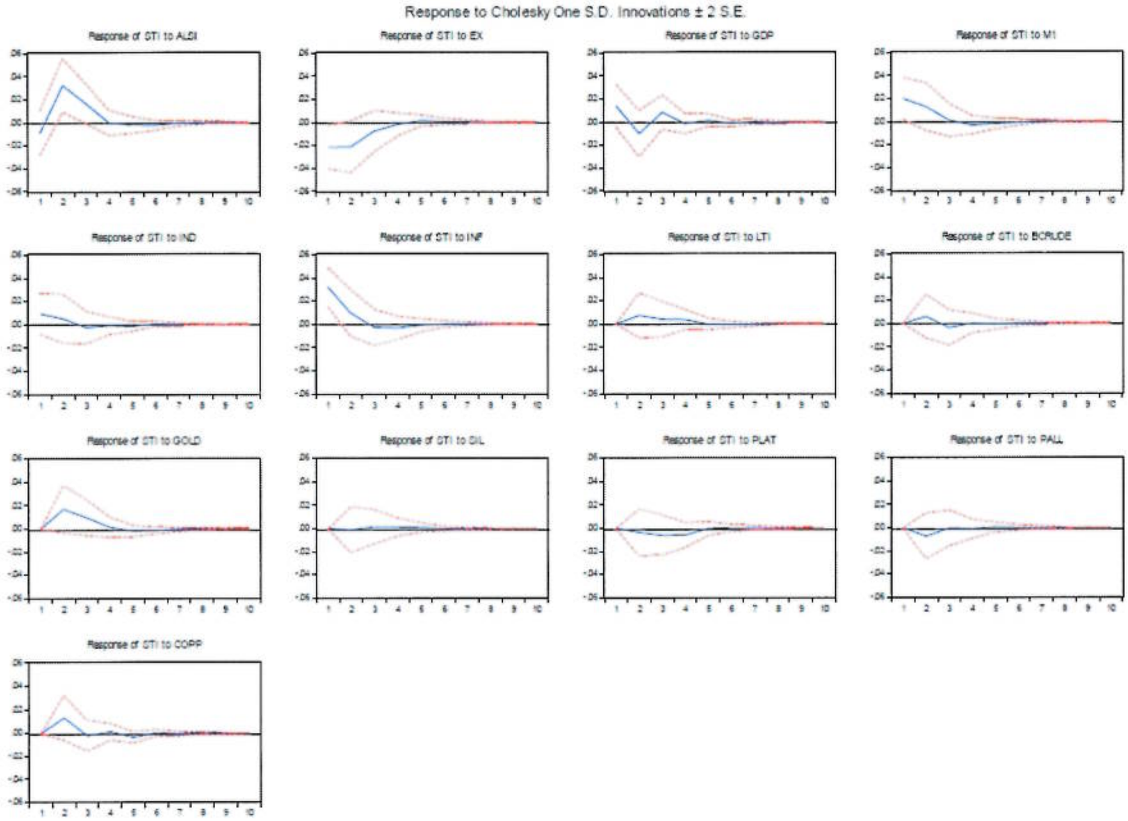


Figure 15: Impulse Response Function of the Long Term Interest Rate

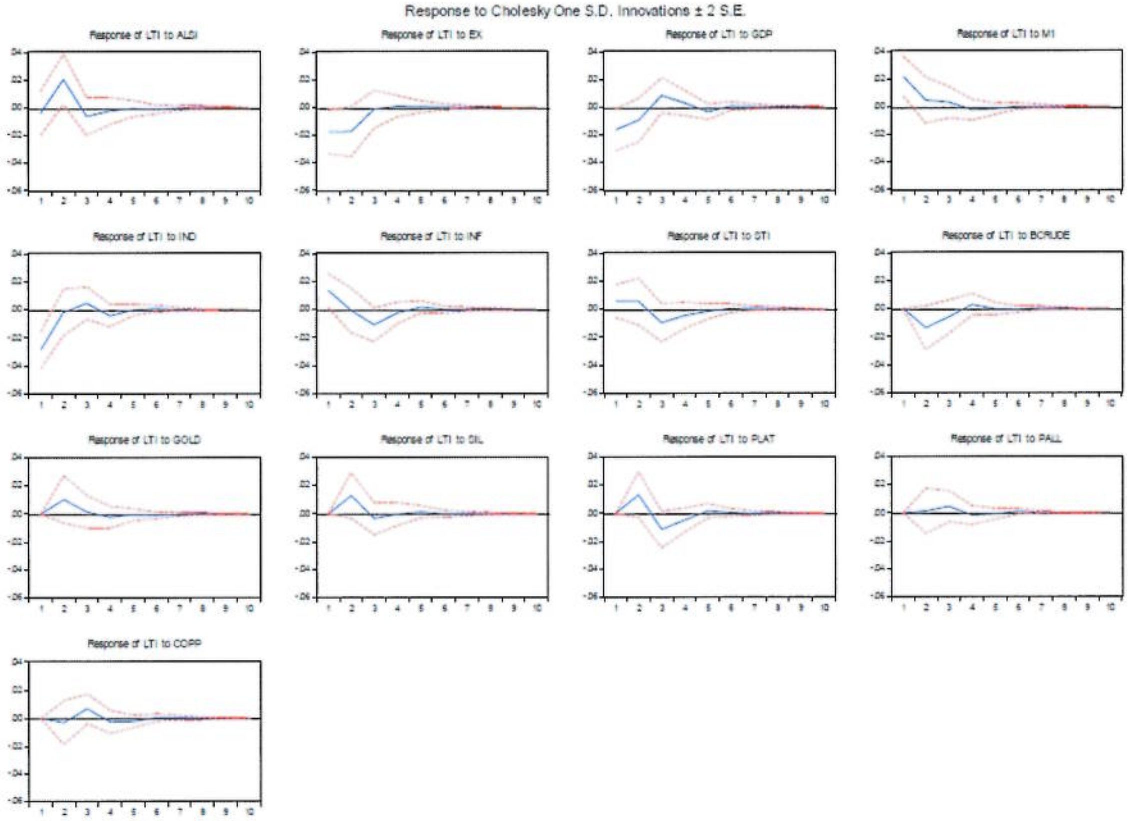


Figure 16: Impulse Response Function of Brent Crude Oil

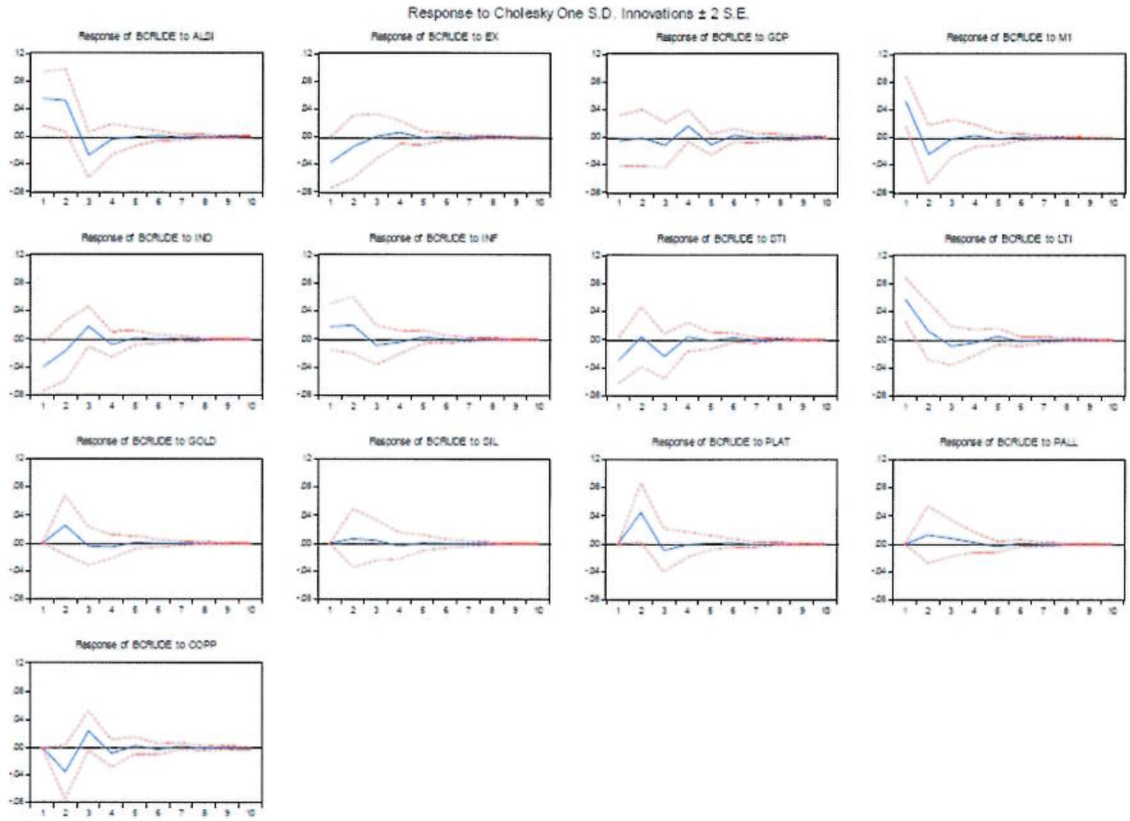


Figure 17: Impulse Response Function of Gold

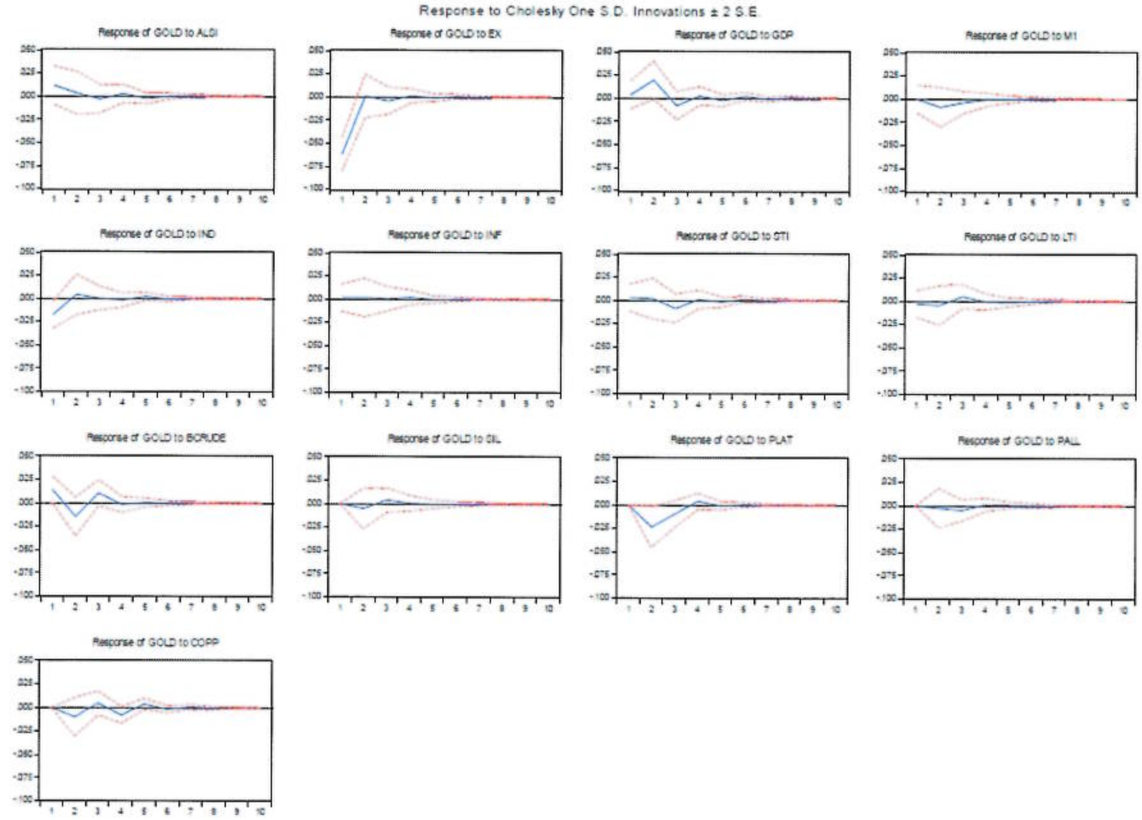


Figure 18: Impulse Response Function of Silver

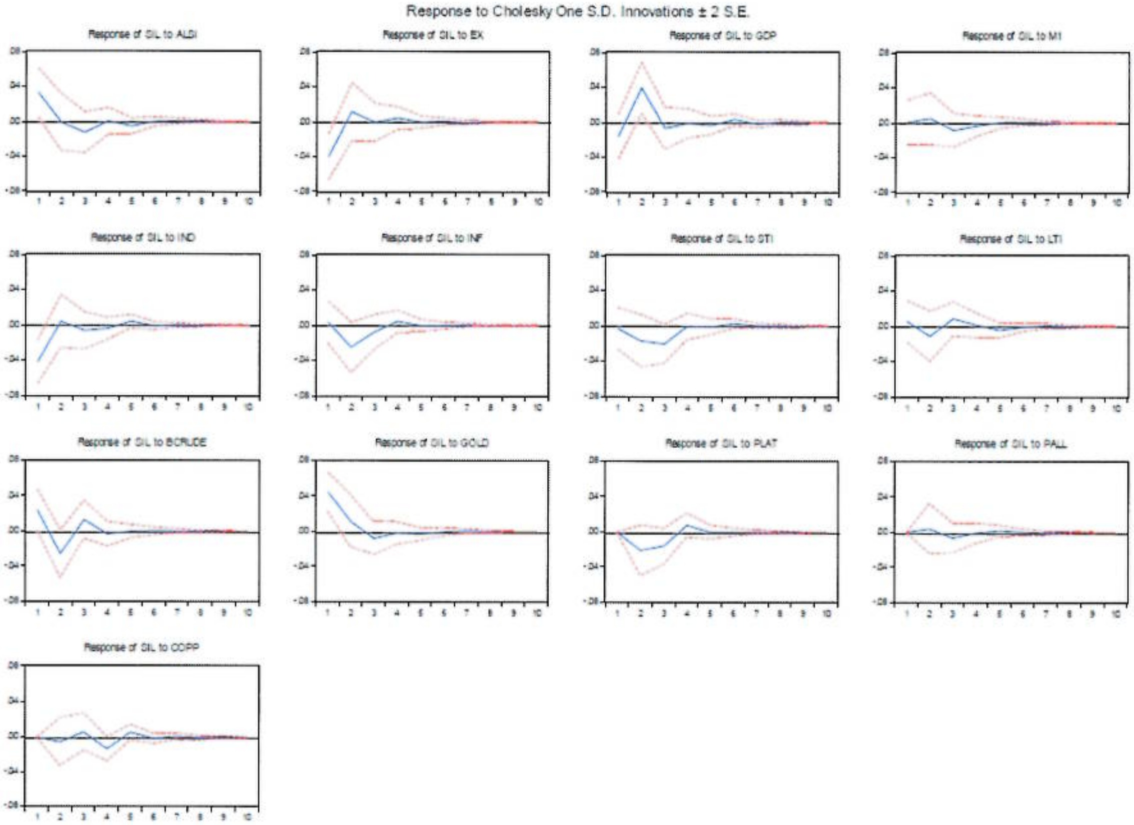


Figure 19: Impulse Response Function of Platinum

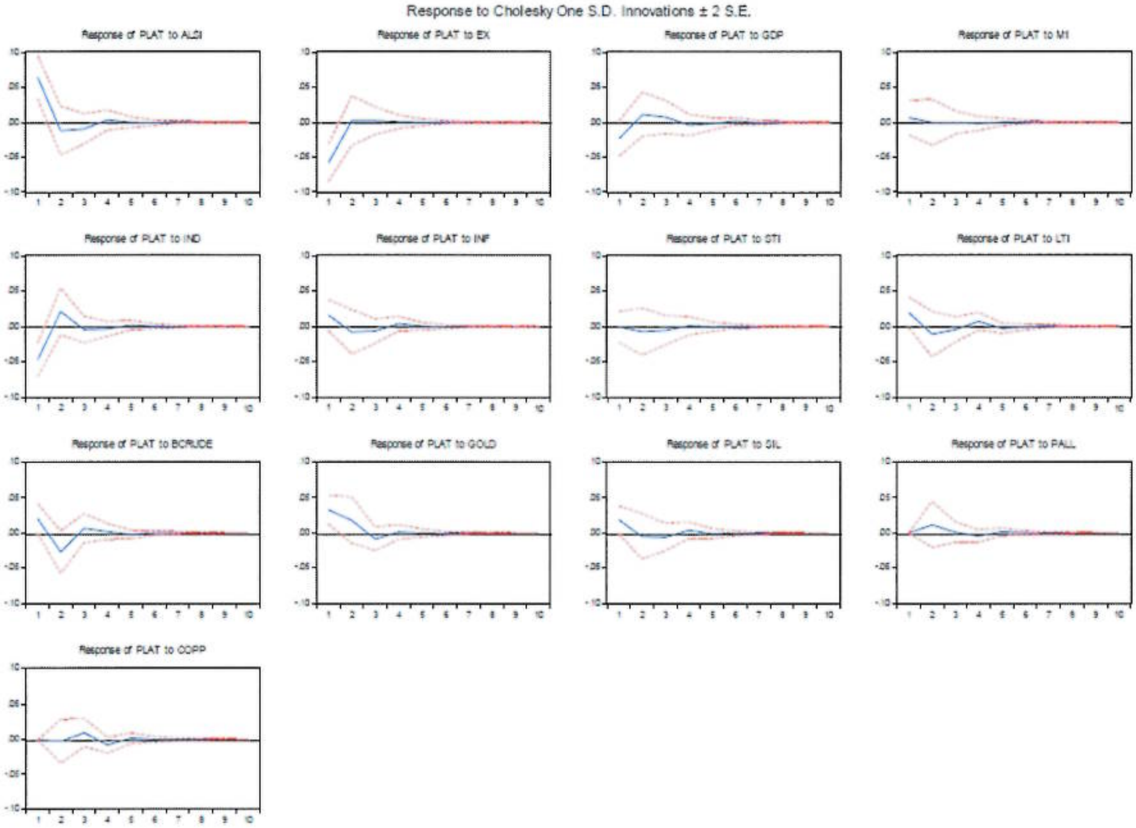


Figure 20: Impulse Response Function of Palladium

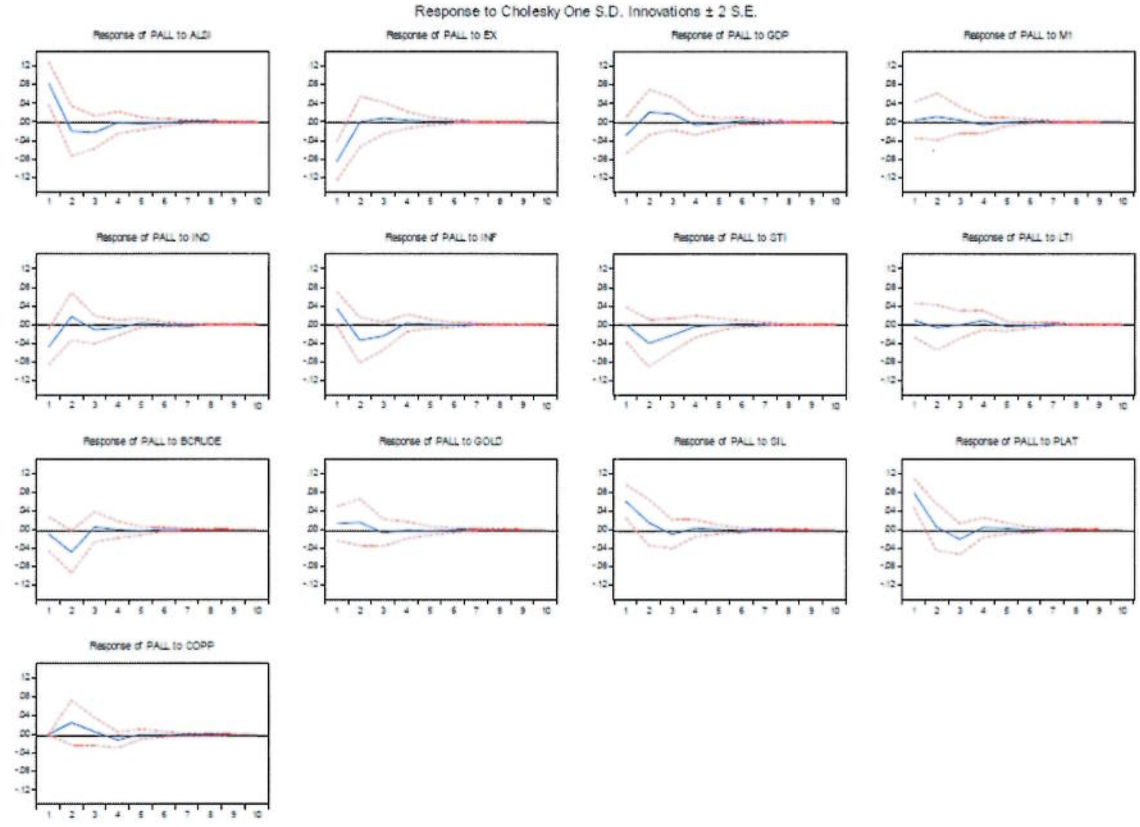
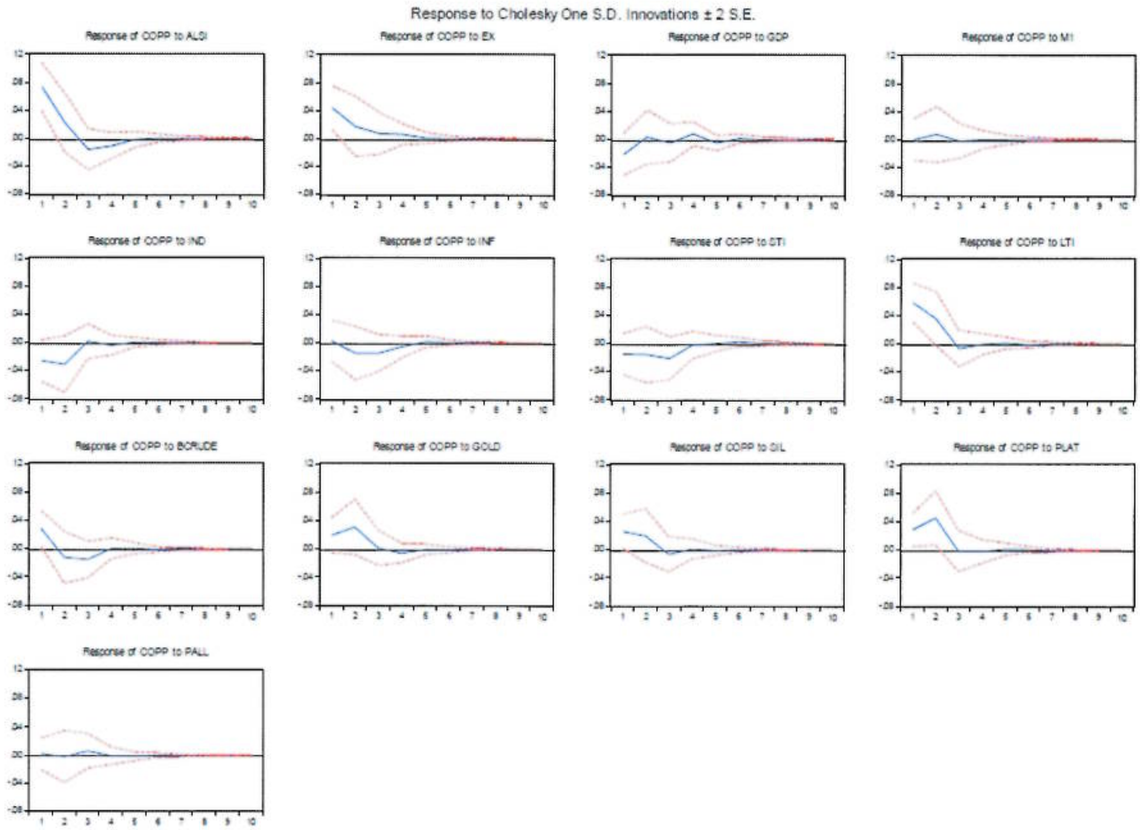


Figure 21: Impulse Response Function of Copper



9.4 APPENDIX D: VAR LAG ORDER SELECTION CRITERIA

Table 69: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1081.612	NA	7.34e-31	-29.65589	-29.21320*	-29.47965
1	1247.963	263.3900	1.83e-30	-28.83232	-22.19204	-26.1888
2	1440.153	229.5603	3.66e-30	-28.72648	-15.88862	-23.61569
3	1726.541	230.7011	1.96e-30	-31.23725	-12.20179	-23.65918
4	2534.162	336.5087*	1.81e-35*	-48.22672*	-22.99367	-38.18137*

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

9.5 APPENDIX E: COINTEGRATION TESTS

Table 71: Cointegration Tests

Date: 02/11/15 Time: 13:21
Sample (adjusted): 5 77
Included observations: 73 after adjustments
Trend assumption: Linear deterministic trend
Series: ALSI EX GDP M1 IND INF STI LTI BCRUDE GOLD SIL PLAT PALL COPP
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.993606	1693.928	NA	NA
At most 1	0.978775	1325.106	NA	NA
At most 2 *	0.959494	1043.869	334.9837	0.0000
At most 3 *	0.918690	809.8099	285.1425	0.0000
At most 4 *	0.902759	626.6177	239.2354	0.0000
At most 5 *	0.825560	456.4864	197.3709	0.0001
At most 6 *	0.676760	329.0155	159.5297	0.0000
At most 7 *	0.609411	246.5723	125.6154	0.0000
At most 8 *	0.558394	177.9451	95.75366	0.0000
At most 9 *	0.469709	118.2794	69.81889	0.0000
At most 10 *	0.342096	71.97335	47.85613	0.0001
At most 11 *	0.282529	41.40849	29.79707	0.0015
At most 12 *	0.159388	17.17082	15.49471	0.0277
At most 13 *	0.059733	4.496160	3.841466	0.0340

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.993606	368.8218	NA	NA
At most 1	0.978775	281.2365	NA	NA
At most 2 *	0.959494	234.0594	76.57843	0.0001
At most 3 *	0.918690	183.1922	70.53513	0.0000
At most 4 *	0.902759	170.1313	64.50472	0.0000
At most 5 *	0.825560	127.4709	58.43354	0.0000
At most 6 *	0.676760	82.44324	52.36261	0.0000
At most 7 *	0.609411	68.62722	46.23142	0.0001
At most 8 *	0.558394	59.66567	40.07757	0.0001
At most 9 *	0.469709	46.30606	33.87687	0.0010
At most 10 *	0.342096	30.56486	27.58434	0.0201
At most 11 *	0.282529	24.23767	21.13162	0.0177
At most 12	0.159388	12.67465	14.26460	0.0878
At most 13 *	0.059733	4.496160	3.841466	0.0340

**MacKinnon-Haug-Michelis (1999) p-values

9.6 APPENDIX F: WEAK EXOGENEITY TESTS

Table 73: Weak Exogeneity Test for the Exchange Rate

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:14
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(2,1)=0	
Convergence achieved after 159 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	10.54989
Probability	0.001162

Table 74: Weak Exogeneity Test for GDP

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:15
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(3,1)=0	
Convergence achieved after 235 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	99.86501
Probability	0.000000

Table 75: Weak Exogeneity Test for Money Supply

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:16
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(4,1)=0
Convergence achieved after 64 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	0.475579
Probability	0.490432

Table 76: Weak Exogeneity Test for Industrial Production

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:16
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(5,1)=0
Convergence achieved after 14 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	7.793118
Probability	0.005245

Table 77: Weak Exogeneity Test for Inflation

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:17
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(6,1)=0
Convergence achieved after 6 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	0.019053
Probability	0.890215

Table 78: Weak Exogeneity Test for the Short Term Interest Rate

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:17
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(7,1)=0	
Convergence achieved after 119 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	7.904617
Probability	0.004931

Table 79: Weak Exogeneity Test for the Long Term Interest Rate

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:17
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(8,1)=0	
Convergence achieved after 66 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	0.397360
Probability	0.528456

Table 80: Weak Exogeneity Test for Brent Crude Oil

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:18
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(9,1)=0	
Convergence achieved after 88 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	2.524203
Probability	0.112111

Table 81: Weak Exogeneity Test for Gold

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:18
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(10,1)=0	
Convergence achieved after 96 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	7.027558
Probability	0.008026

Table 82: Weak Exogeneity Test for Silver

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:19
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(11,1)=0	
Convergence achieved after 64 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	1.140015
Probability	0.285649

Table 83: Weak Exogeneity Test for Platinum

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:19
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(12,1)=0	
Convergence achieved after 4 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	0.026586
Probability	0.870478

Table 84: Weak Exogeneity Test for Palladium

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:20
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(13,1)=0	
Convergence achieved after 5 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	0.036247
Probability	0.849007

Table 85: Weak Exogeneity Test for Copper

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:20
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, A(14,1)=0	
Convergence achieved after 5 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	0.009136
Probability	0.923854

9.7 APPENDIX G: LONG RUN EQUILIBRIUM RELATIONSHIPS

Table 86: Long Run Equilibrium Relationship between the Exchange Rate and GDP

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:41
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,2)=B(1,3)	
Convergence achieved after 27 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	122.8699
Probability	0.000000

Table 87: Long Run Equilibrium Relationship between the Exchange Rate and Industrial Production

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:41
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,2)=B(1,4)	
Convergence achieved after 303 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	5.786266
Probability	0.016152

Table 88: Long Run Equilibrium Relationship between the Exchange Rate and the Short Term Interest Rate

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:42
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,2)=B(1,5)	
Maximum iterations (500) reached.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	2.561847
Probability	0.109471

Table 89: Long Run Equilibrium Relationship between the Exchange Rate and Gold

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:42
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,2)=B(1,6)	
Maximum iterations (500) reached.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	0.424031
Probability	0.514932

Table 90: Long Run Equilibrium Relationship between GDP and Industrial Production

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:43
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,3)=B(1,4)	
Convergence achieved after 22 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	122.4585
Probability	0.000000

Table 91: Long Run Equilibrium Relationship between GDP and the Short Term Interest Rate

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:44
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,3)=B(1,5)	
Convergence achieved after 28 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	123.4187
Probability	0.000000

Table 92: Long Run Equilibrium Relationship between GDP and Gold

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:44
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,3)=B(1,6)	
Convergence achieved after 30 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	123.5621
Probability	0.000000

Table 93: Long Run Equilibrium Relationship between Industrial Production and the Short Term Interest Rate

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:44
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,4)=B(1,5)	
Convergence achieved after 238 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	3.671051
Probability	0.055365

Table 94: Long Run Equilibrium Relationship between Industrial Production and Gold

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:45
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,4)=B(1,6)	
Convergence achieved after 444 iterations.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	7.465527
Probability	0.006289

Table 95: Long Run Equilibrium Relationship between the Short Term Interest Rate and Gold

Vector Error Correction Estimates
Date: 02/11/15 Time: 14:45
Sample (adjusted): 4 76
Included observations: 73 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:	
B(1,1)=1, B(1,5)=B(1,6)	
Maximum iterations (500) reached.	
Restrictions identify all cointegrating vectors	
LR test for binding restrictions (rank = 1):	
Chi-square(1)	1.093554
Probability	0.295685