THE DYNAMIC RELATIONSHIP BETWEEN ECONOMIC FACTORS AND THE SOUTH AFRICAN STOCK MARKET

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ABSTRACT

This study examines the long-term equilibrium relationship between macroeconomic variables and the Johannesburg Stock Exchange (JSE) using quarterly data from 1994 to 2012. The macroeconomic variables tested are inflation, the short-term interest rate, the long-term interest rate, the foreign exchange rate, the money supply, industrial production, the Gross Domestic Product (GDP), the oil price and the gold price. A Vector Error Correction Model (VECM) is employed to determine the long-run equilibrium relationship and any short-run interactions among the variables. The results indicate that the JSE has significant positive long-run relationships with inflation and GDP and a significant negative relationship with the money supply. The results imply that a multi-factor model is appropriate for asset pricing in South Africa.

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1 INTRODUCTION

A substantial amount of literature concerns the behaviour of stock prices and returns, particularly, the factors driving returns. The Capital Asset Pricing Model (CAPM) and the Arbitrage Pricing Theory (APT) emerged as two models that aim to explain stock prices and returns. Both models are based on the Efficient Market Hypothesis (EMH) (Fama, 1965) which states that at any given time, security prices fully reflect all available information.

The CAPM, developed by Treynor (1961), Sharpe (1964) and Lintner (1965), has remained the most popular asset pricing model due to its intuitive and simplistic nature. It is a linear, ex ante concept describing the relationship between risk and return. According to the model, beta is the only relevant risk measure. Therefore, if the CAPM is ‘true’, beta should suffice as an explanation for the cross-sectional variation in share returns. On this implication rests some of the main arguments against the CAPM. In the 1980s, several studies identified additional factors that describe returns. Banz (1981) found that size adds explanatory power to the cross-section of average returns provided by the market beta, and Basu (1983) found that value stocks (as measured by E/P) experienced larger returns than the CAPM predicted. Consequently, researchers have suggested that the CAPM is incorrect and that a multi-factor asset pricing model is instead appropriate. Other attacks on the CAPM are based on the assumptions underlying the model that appear to be unrealistic in the real world, the most stringent of them being the identification of the mean-variance efficient portfolio. Roll (1977) bases his critique of the CAPM on the unreasonableness of this assumption. The author exposes the futility of the empirical tests on the CAPM and concludes that it is not a testable scientific theory.

In 1976, Ross introduced the APT as an alternative to the CAPM suggesting that only a small number of systematic influences affect the long-term average returns on securities. APT states that the returns on securities are linearly related to a number of common or systematic factors rather than a single market factor. On both empirical and theoretical grounds, the APT is considered the more attractive model; allowing returns to be modeled using multiple factors, unlike the CAPM, enhances the explanatory power of the APT and often, the model is able to explain the anomalies arising from the application of the CAPM to asset returns (Dhrymes, Friend & Gültekin, 1984).

Theoretically, the APT is also more appealing as it requires less restrictive and more plausible assumptions (Van Rensburg, 1997).

The main criticism of the APT is that it neither stipulates the identity of the underlying factors, nor the appropriate number of factors that are required to model asset prices. Since its development, researchers have been concerned with solving these issues. It is now a well-established finding that asset prices are driven by macroeconomic variables (see Fama, 1981; Fama, 1990; Chen, Roll & Ross, 1986; Ferson & Harvey, 1991). Macroeconomic factors impact discount rates, the ability of firms to generate cash flows, the way traders and investors form expectations, and future dividend payouts of the firm. It is through these mechanisms that they may become risk factors priced in equity markets (Maysami & Koh, 2000).

There has been a wealth of studies seeking to measure the risk premia attached to economic risk factors and to assess their significance. Most of the early APT tests employ factor analysis techniques to do so. Factor analysis is useful as the factors identified from the data explain a large proportion of the variation in the particular sample under consideration. However, a major drawback of this method is its inability to determine the nature of common factors since they are treated as inherently latent (Maysami & Koh, 2000).

An alternative, more promising approach to factor analysis, is that which tests a set of pre-specified macroeconomic factors. This approach makes use of various statistical techniques to examine whether the sensitivity coefficients of stock returns to these pre-specified factors are able to explain the cross-sectional variation of average returns (Hamao, 1986). Chen et al. (1986) conducted one of the first empirical studies that used observed factors. The authors employed the Fama and MacBeth (1973) style cross-sectional regressions and provided the basis for the view that a long-run relationship exists between stock prices and economic factors. With the development of cointegration analysis, this long-run relationship may be assessed (Engle & Granger, 1987; Granger, 1986).

The objective of this study is to empirically test the long-run relationship between several macroeconomic factors and share prices on the JSE using a post-Apartheid sample period. In doing so, Johansen’s (1991) cointegration procedure and Vector Error Correction Model (VECM) will be employed. The use of cointegration techniques is advantageous as it has the ability to explore dynamic co-movements among the variables through an error correction model (Mukherjee &

Naka, 1995). The macroeconomic factors that will be analysed with respect to the JSE are the foreign exchange rate, the money supply, industrial production, the oil price, the gold price, inflation, GDP, the short-term interest rate and the long-term interest rate.

2 IMPORTANCE AND BENEFITS OF STUDY

There is a substantial body of research concerning the relationship between macroeconomic variables and stock prices and these studies utilise various methodologies. However, little research on this subject has been conducted in the South African context, especially research using the VECM approach.

The most notable empirical investigation on the relationship between economic factors and the JSE was conducted by Van Rensburg (1995, 1998, 1999). However, the study's sample period spanned the Apartheid era in South African history. In this period, South Africa's economy was crippled by economic sanctions, international disinvestment and trading restrictions. Jefferis and Okeahalam (2000) present one of the first South African studies to employ cointegration techniques, however, their sample period also covered a period during Apartheid.

This study will address the need for more recent, post-Apartheid evidence on the long-run relationship between macroeconomic factors and stock prices on the JSE. This is necessary given that the South African stock market has transformed significantly since the abolition of Apartheid and continues to undergo technical changes; this evolution is likely to have increased the efficiency of the South African stock market, therefore increasing its response to macroeconomic events. Additionally, the study will contribute to the existing literature by employing a VECM, which has become a standard and more appropriate technique for examining cointegration among financial variables. The study will also be useful as it will potentially confirm or reject the variables of importance identified by Van Rensburg (1995, 1998, 1999) and Jefferis and Okeahalam (2000); it may even introduce new variables of statistical significance. Furthermore, the study's findings may shed light on stock market responses to macroeconomic factors for similar emerging and resource-based markets.

3 LITERATURE REVIEW

The literature review will proceed as follows: It will first address the existing literature in the United States (US) on the relationship between macroeconomic variables and stock prices.

Thereafter, it will discuss evidence in other developed markets. It will then review work conducted in developing markets and lastly, it will discuss previous studies conducted in South Africa.

3.1 EVIDENCE FROM THE US

Real economic activities are commonly believed to affect stock prices. Fama (1981) argued that changes in real economic activities affect the consumption and investment opportunity set and since these changes are priced in capital markets, stock price changes are linked to innovations in economic state variables. Chen et al. (1986) contend that economic variables affect stock prices through their effects on future dividends and discount rates. In general, asset prices respond to economic events and news with some events having a more pervasive effect on prices than others (Chen et al., 1986).

Early empirical investigations on the APT focused on estimating asset sensitivities to unknown factors using exploratory factor analysis on stock returns. Roll and Ross (1980) tested the APT using daily data for equities listed on the New York Stock Exchange (NYSE). The authors found that three or four systematic risk factors were adequate to explain asset returns in the period 1962 to 1972. Chen (1983) compared the empirical performance of the APT with that of the CAPM and found evidence in favour of the APT. Analysing stocks on the NYSE and American Exchange (AMEX) from 1963 to 1978, the author found that five factors are required to explain returns. However, Dhrymes, Friend, Gültekin and Gültekin (1985) documented that the appropriate number of factors is dependent on the length of the sample period and the size of the stock groups under analysis.

Several other studies modeled relationships between share prices and real economic activities. These studies were characterised by pre-specifying general factors that could explain asset pricing in the stock market. Economic factors affecting the future cash flows of firms or future risk-adjusted discount rates were usually the variables that were pre-specified. Fama (1981) documented a strong positive relationship between stock returns and capital expenditure, industrial production, the gross national product, the money supply, lagged inflation and the interest rate. Numerous other studies present evidence of significant relationships between stock market returns and macroeconomic variables (see Geske & Roll, 1983; Huang & Kracaw, 1984; Fama, 1990; Schwert, 1990; Ferson & Harvey, 1991; Black, Fraser & MacDonald, 1997).

Chen et al. (1986) present one of the most cited empirical tests of the APT using observed macroeconomic variables. The authors identified five macroeconomic variables that affected share returns on the NYSE during the period 1958 to 1984: industrial production, the change in expected inflation, unexpected inflation, the risk premium and the term structure of interest rates. Chen (1991) found that domestic variables (the lagged production growth rate, the default premium, the term premium, the short-term interest rate, and the market dividend price ratio) are indicators of current and future economic growth. These findings confirm those of Chen et al. (1986) suggesting that domestic variables have forecasting ability with respect to excess market returns via their forecast of the macroeconomy.

Dhakal, Kandil and Sharma (1993) investigated the interactions between the money supply and US share prices based on the money market equilibrium condition using a vector autoregressive technique. Their results indicate that changes in the money supply have significant direct and indirect (via real output, inflation and interest rates) effects on the variability of stock prices in the US. Abdullah and Hayworth (1993) found that growth in the money supply and inflation are positively related to US stock returns while budget and trade deficits and short and long-term interest rates negatively impact returns.

3.2 EVIDENCE FROM OTHER DEVELOPED MARKETS

Following Chen et al. (1986), researchers began to investigate the relationship between macroeconomic variables and stocks in markets outside of the US. Poon and Taylor (1991) analysed the effect of macroeconomic variables similar to those of Chen et al. (1986) on stocks in the United Kingdom (UK). The authors found that the interrelationships between the variables and stock prices in the UK are vastly different from those described by Chen et al. (1986). Clare and Thomas (1994) tested the impact of 18 macroeconomic factors on UK stocks. The authors found that the oil price, retail price index, bank lending and corporate default risk had significant effects on stock returns. In a more recent study, Günsel and Çukur (2007) examined the effects of the interest rate, the risk premium, the exchange rate, the money supply and inflation on stock market returns in the UK. The authors found that macroeconomic factors indeed play a significant role on asset returns; however, the regression results revealed differences among industry portfolios, suggesting that the effects of each factor depend significantly on the industry. Nasseh and Strauss (2000) analysed the long-run relationship between internal and external economic factors, and stock prices in Germany, Italy, France, Netherlands and the UK. Their findings suggest that the Consumer

Price Index (CPI), industrial production, interest rates and business expectations significantly impact stock price movements in those markets.

Martikainen, Yli-Olli and Gunasekaran (1991) tested the APT in the Finnish stock market. Using two different approaches (exploratory factor analysis and a pre-specified macroeconomic factor approach), the authors sought to determine the number of factors affecting Finnish stocks in two time periods: 1977 to 1981 and 1982 to 1986. The authors pre-specified eleven macroeconomic factors and found only one significant factor for the first sub-period. In the second sub-period, all factors were significant thus supporting the usage of an economic, multi-factor model. Booth, Martikainen, Virtanen and Yli-Olli (1993) tested the APT in the US, Finnish and Swedish markets between 1977 and 1986. The authors examined the intra-country stability of the factor patterns over time and across different samples using transformation analysis. Two stable common factors in different samples were found. In addition, the authors found evidence of two priced common factors across the first US, Finnish and Swedish samples. This suggests that these two factors may have been global by nature. Overall, their results imply that while the APT performs well in the US and Sweden, its performance in Finland is relatively poor.

Hamao (1988) replicated the study of Chen et al. (1986) on Japanese data. The author’s findings indicate that Japanese stock returns are significantly affected by changes in expected inflation, and unexpected changes in both the risk premium and the slope of the term structure of interest rates. In addition, the study notes that the volatility in real economic activity in Japan is weakly priced in comparison to the US. Brown and Otsuki (1990) also analysed the Japanese market and found that the money supply, production index, crude oil price, exchange rate, call money rate and a residual market error are related to risk premia and therefore affect stock prices. Mukherjee and Naka (1995) tested the dynamic relationship between the Tokyo Stock Exchange and six macroeconomic variables (exchange rate, money supply, inflation, industrial production, long-term government bond rate and call money rate) using a VECM. Their results indicate that all six macroeconomic variables form a relationship with the stock exchange in the long-run. More recently, Humpe and Macmillan (2009) compared the reactions of the US and Japanese stock markets to changes in macroeconomic factors using cointegration techniques. Although there are some differences in market responses to the same variables, the evidence shows that a cointegrating vector between stock market returns and factors such as industrial production and the money supply exists in both the US and Japan. Kwon and Shin (1999) analysed the relationships between four macroeconomic factors and Korean stock indices. Using the VECM approach, they found that the production index, exchange rate, trade balance, and money supply have a direct, long-run equilibrium relation with each stock index examined. However, the authors noted that stock indices are not leading indicators for economic variables. This result opposes the view that that the stock market rationally signals changes in real activities (Fama, 1991; Geske & Roll, 1983). Maysami and Koh (2000), using similar techniques, examined the long-run relationship between macroeconomic factors and stock prices on the Stock Exchange of Singapore. Their study reveals the sensitivity of Singapore's stock market to interest and exchanges rate changes. Maysami, Lee and Hamzah (2004) showed that in addition to the Singaporean stock market's sensitivity to interest rate changes, the exchange has positive, priced relationships with inflation, the money supply and the level of real economic activity.

Groenewold and Fraser (1997) focused their research on the Australian market. The authors chose their analysis variables based on the hypothesis that returns are influenced by three classes of factors: real domestic activity, nominal domestic influences and foreign variables. Their findings suggest that Australian stocks are affected mainly by the inflation rate and monetary variables. By contrast, Paul and Mallik (2003) found that inflation has an insignificant effect on equity prices in the banking and finance sector in Australia. Instead, the authors found that the interest rate and growth in Gross Domestic Product (GDP) are significant explanatory variables.

3.3 EVIDENCE FROM DEVELOPING MARKETS

There has been a growing number of studies conducted in developing markets on the relationship between macroeconomic variables and share prices. Attaullah (2001) tested the APT on the Karachi Stock Exchange using monthly data between 1993 and 1998. Employing an Iterative Non-Linear Seemingly-Unrelated Regressions technique, the author found that unexpected inflation, the exchange rate, trade balance and world oil prices were significant sources systematic risk. Abeyratna, Pisedtasalasai and Power (2004) focused their research on the Sri Lankan stock market. The authors tested the long and short-run relationships between four macroeconomic factors and the Colombo All Share Index over a 17 year period. The results of the VECM analysis indicate that the lagged values of the CPI, money supply and treasury bill rate have significant effects on the stock market. Wongbangpo and Sharma (2002) examined the relationship between macroeconomic variables and stock returns in Indonesia, Malaysia, Philippines, Singapore and Thailand. The authors observed short and long-run relationships between stock prices and the following variables: gross national product, CPI, the money supply, the interest rate and the exchange rate.

Kandir (2008) analysed the effects of seven macroeconomic factors (growth rate of the industrial production index, changes in the CPI, growth rate of money supply, changes in exchange rate, interest rate, growth rate of international crude oil price and return on the MSCI World Equity Index) on Turkish stock portfolios for the period 1997 to 2005. The study found that the exchange rate, interest rate and world market return affect the returns of all stock portfolios, while industrial production, the money supply and oil prices did not appear to have any significant effects. Interestingly, the inflation rate was significant for only three of the twelve portfolios.

Omran (2003) made use of an Error Correction Model (ECM) to establish the relationship between the real interest rate and stock prices in Egypt. The author concludes that the real interest rate significantly impacts the performance of Egyptian equities. Adjasi and Biekpe (2006) investigated the relationship between exchange rate movements and stock market returns in seven African countries using cointegration analysis. Their empirical findings suggest that in the long-run (short-run) exchange rate depreciation leads to increases (decreases) in stock market returns in most of the countries analysed. Isenmila and Erah (2012) examined the suitability of the APT in explaining stock returns in Nigeria. Using cointegration and error correction methodology, the authors found that the money supply, the exchange rate, the interest rate and oil prices significantly impact returns in both the short and long-run. In an interesting study by Adam and Tweneboah (2008), a positive relationship was found between inflation and stock returns for Ghana. The authors argue this finding to be indicative of investor compensation for inflationary pressures.

3.4 EVIDENCE FROM SOUTH AFRICA

Early tests of the APT in the South African market employed factor analysis. Page (1986) analysed the period 1973 to 1982 and documented two priced factors relating to the mining and industrial sectors. Barr (1990) also used factor analysis and found that the gold price, short-term interest rate, foreign stock markets and local business confidence impact South African stock returns significantly.

Van Rensburg (1995, 1998, 1999) made one of the largest contributions to the literature on modeling returns on the JSE with macroeconomic variables (Moolman & du Toit, 2005). Van Rensburg (1995) found that the following variables formed significant linear relationships with stock prices on the JSE: changes in the term structure, returns on the NYSE, changes in inflation and changes in the gold price. Van Rensburg (1998) studied the relationships between economic factors and stock prices using bivariate Granger causality and correlation tests. The author focused his analysis on the effects of three classes of variables: factors that influence the discount rate, factors that impact dividends and international factors. In addition to analysing the overall JSE index, Van Rensburg (1999) examined the effects of several macroeconomic variables on the returns of the JSE's industrial and gold indices. The study's findings indicate that the long-term interest rate, the gold and foreign reserve balance and the balance on the current account significantly impact all three indices. The effects of the short-term interest rate were only significant with respect to the returns on the Dow Jones Industrial Index, while the price of gold and the exchange rate were only influential on the performance of the gold index.

Jefferis and Okeahalam (2000) conducted one of the first cointegration analyses on the South African stock market. Using quarterly data between 1985 and 1995, the authors found that in the long-run, real stock prices are positively related to the exchange rate and GDP, and negatively related to long-term interest rates. In a more recent study, Moolman and du Toit (2005) examined the short-term and long-term relationships between domestic and international factors, and the JSE. The authors developed a structural model of the South African stock market using cointegration and error correction techniques. According to their model, share prices are cointegrated with variables dictated by the expected present value model of asset price determination. However, their sample period (1978-2000) only captured six years of post-Apartheid data.

4 RESEARCH DESIGN

This study adopts a time-series research design to examine the long-run relationship between nine macroeconomic variables and stock prices. Specifically, the cointegration procedure outlined by Johansen (1991) will be employed.

A set of time-series variables are said to be cointegrated if they are integrated of the same order and a linear combination of the variables is stationary (Maysami & Koh, 2000). The presence of such linear combinations points to the existence of a long-run relationship among the variables (Granger, 1986; Johansen & Juselius, 1990).

Relative to the standard Vector Autoregression (VAR) model (which is often used to examine the relationship between stock returns and economic factors), cointegration analysis is a more advantageous framework; the cointegration method has the ability to explore dynamic co-movements among the variables through an ECM (Mukherjee & Naka, 1995). Additionally, in the presence of a cointegrating vector, the VAR analysis becomes erroneous after differencing the data set of time series variables; the linear combination of variables is already a stationary time series and differencing the relationship entails a misspecification error (Mukherjee & Naka, 1995).

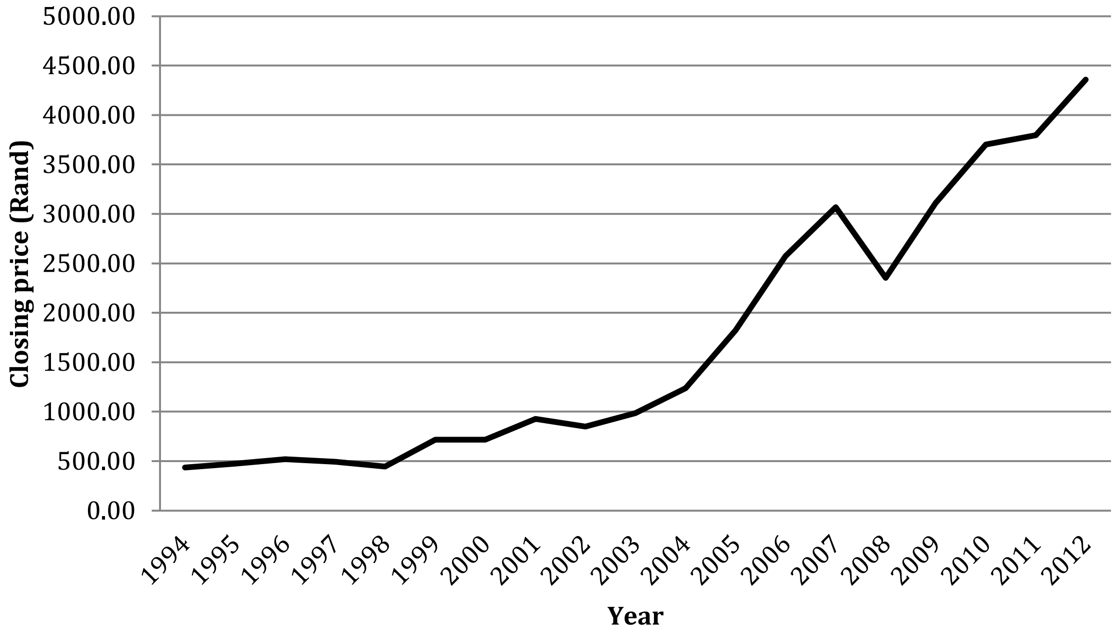
Engle and Granger (1987) provide a method of testing for cointegration in a univariate framework. While their two-step ECM may be employed, this study adopts the multi-variate estimation of the VECM developed by Johansen (1991). The VECM yields more efficient estimators of cointegrating vectors than the ECM (Phillips, 1991). It is a full information maximum likelihood estimation model that allows for the testing of cointegration in a whole system of equations in a single step. Furthermore, unlike the ECM, the VECM does not require a specific variable to be normalised and has the capability of treating all variables as endogenous. The findings of Gonzalo (1994) support the methodology choice of this study. Using simulation analysis, the author tested five techniques for estimating long-run relationships. His findings indicate that estimates resulting from Johansen's VECM had better properties than the estimates provided by the other techniques.

4.1 SAMPLING AND DATA COLLECTION

Closing prices of the JSE All Share Index (ALSI) between May 1994 and September 2012 will form the sample of South African stock prices. The start date was chosen as it marks the first democratic elections of South Africa, and South Africa's reintegration into the world economy since the abolition of Apartheid. The end date was chosen as it is the most recent data that may be analysed. The sample period is also useful as it accounts for two financial crises.

The study will use quarterly data i.e. quarterly data on the chosen macroeconomic variables will be tested against quarterly closing prices of the JSE ALSI. Data is obtained from I-Net Bridge and McGregor BFA. The annual closing prices on the JSE ALSI during the sample period are displayed in Figure 1.

Figure 1: Closing prices of the JSE ALSI (1994-2012)



4.2 CANDIDATE MACROECONOMIC VARIABLES

According to the Gordon and Shapiro (1956) model, the price of a share is equal to the discounted sum of expected future dividends. However, Miller and Modigliani (1961) argue that the underlying source of a firm's value is derived from earnings as dividends are merely payouts funded by earnings. Therefore, it follows that the systematic factors influencing stock prices are those that impact expected earnings and the discount rate. Indeed, many previous studies based their selection of macroeconomic variables on the logic explained above.

No claim is made that the macroeconomic variables chosen in this study provide an exhaustive source of stock price volatility. The selection of variables is based on both their theoretical relevance and on existing empirical studies.

The following factors will be tested: the long-term interest rate, the short-term interest rate, inflation, the foreign exchange rate (Rand/US Dollar), money supply, GDP, industrial production, the oil price and the gold price. The long-term interest rate will be approximated by the ten year government bond rate. The 90-day bankers' acceptance rate will represent the short-term interest rate and inflation will be proxied by the CPI. Although theoretically, the price of gold is not a macroeconomic variable, it is included as a candidate variable as it is likely to impact South African stocks, particularly those in the mining sector. In order to address the high variability and unevenness of the data, all variables will be log transformed.

Table 1: Definitions of variables and time series transformations

Variable	Definition
Share Price (JSE)	Natural logarithm of quarterly closing prices of the JSE ALSI.
Inflation (CPI)	Natural logarithm of the quarter-end Consumer Price Index.
Exchange Rate (EX)	Natural logarithm quarter-end price (Rand) of a US dollar.
Gross Domestic Product (GDP)	Natural logarithm of quarterly GDP.
Gold Price (GP)	Natural logarithm of the gold price (US Dollars per an ounce).
Industrial Production (IP)	Natural logarithm of the quarterly industrial production.
Short-term Interest Rate (IR)	Natural logarithm of the 90 day bankers' acceptance rate.
Long-term Interest Rate (LGB)	Natural logarithm of the 10 year government bond yield.
Money Supply (M3)	Natural logarithm of the quarter-end supply of money.
Oil Price (OP)	Natural logarithm of Brent crude price (US Dollars per barrel).
Transformation	**Definition**
$\Delta JSE_t = JSE_t - JSE_{t-1}$	Quarterly return on the JSE.
$\Delta CPI_t = CPI_t - CPI_{t-1}$	Quarterly change in the rate of inflation.
$\Delta EX_t = EX_t - EX_{t-1}$	Quarterly change in the Rand/Dollar exchange rate.
$\Delta GDP_t = GDP_t - GDP_{t-1}$	Quarterly change in GDP.
$\Delta GP_t = GP_t - GP_{t-1}$	Quarterly return on gold.
$\Delta IP_t = IP_t - IP_{t-1}$	Quarterly change in industrial production.
$\Delta IR_t = IR_t - IR_{t-1}$	Quarterly change in the short-term interest rate.
$\Delta LGB_t = LGB_t - LGB_{t-1}$	Quarterly change in the long-term government bond rate.
$\Delta M3_t = M3_t - M3_{t-1}$	Quarterly growth rate of the money supply.
$\Delta OP_t = OP_t - OP_{t-1}$	Quarterly return on oil.

4.3 HYPOTHESISED RELATIONSHIPS

The following hypotheses were developed based on 'simple and intuitive financial theory' (Mukherjee & Naka, 1995):

4.3.1 Interest rates

Interest rate volatility is critical in asset pricing and its most obvious impact is on the discount rate. A negative relationship is expected between interest rates and stock prices; a higher interest rate implies a higher discount factor and this inversely impacts stock prices. However, the interest rate also affects stock prices via its effects on equity demand and corporate profitability. From the perspective of asset allocation, a high interest rate (representing the opportunity cost) may influence investors to substitute equities in their portfolio with other financial assets, thereby decreasing the demand for stocks. In addition, rising interest rates impose greater financing costs on corporates, resulting in decreased profitability and depressed stock prices. Chen et al. (1986) provide empirical support for this hypothesised negative relationship.

4.3.2 Inflation

It is generally observed that inflation and stock prices have an inverse relationship (Fama, 1981; Chen et al., 1986). An increase in expected inflation impacts stock prices through its positive effects on interest rates. Additionally, in a competitive economy, inflation increases the production costs of a firm, decreasing its future cash flows and its share price (DeFina, 1991). A negative relationship is thus anticipated between inflation and stock prices.

4.3.3 Exchange rate

A positive relationship between the exchange rate and South African share prices is hypothesised. The appreciation of the Rand results in a relative increase in the price of South African products in the world market. This decreases the demand for South African exports hence decreasing cash inflows to the country. Conversely, the depreciation of the Rand makes local goods cheaper for foreigners, leading to an increase in domestic exports, and larger capital inflows.

4.3.4 Money supply

Several studies have found a significant effect of the money supply on stock prices. However, the direction of its impact is an empirical question. An increase in the money supply can have positive effects on stock prices (Dhakal et al., 1993); *ceteris paribus*, an increase in the money supply creates an excess supply of money balances and an excess demand for equities, causing stock prices to increase. On the other hand, an increase in the money supply may also put downward pressure on share prices through its positive impact on inflation.

4.3.5 Gross Domestic Product (GDP)

GDP measures the total value of all goods and services produced by a country in a given year. Therefore, GDP growth represents an important indicator of economic performance. A positive relationship is hypothesised between GDP and stock prices; a higher level of output implies an increase in cash flows and corporate profitability, thus resulting in the appreciation of the overall stock market.

4.3.6 Industrial production

Industrial production measures real output and is an important forecasting tool. While it forms part of GDP, the impact of industrial production is analysed separately as it is highly sensitive to interest rates and consumer demand. Chen et al. (1986) suggest a positive relationship between stock returns and industrial production; an increase in industrial production would have a positive impact on GDP and corporate profitability thus resulting in stock price increases.

4.3.7 Oil price

A negative relationship is hypothesised between the oil price and stock prices. Intuitively, an increase in oil prices increases the production costs of corporates and decreases shareholder value (Filis, Degiannakis & Floros, 2011). This negative relationship has been empirically proven in a number of studies (see Kaul & Seyhun, 1990; Jones & Kaul, 1996).

4.3.8 Gold price

South Africa is one of the leading exporters of gold and it is likely that share prices on the country's resource-heavy stock exchange are related to the gold price. This study hypothesises a positive relationship between the gold price and stock prices; gold price increases are representative of an increased demand for gold, and thus larger capital inflows to South Africa.

4.4 METHODOLOGY

Two series (stationary or non-stationary) are said to be cointegrated if combining them in a statistical equation results in a stationary error term (Al-Sharkas, 2004). The existence of cointegration among variables indicates that these variables form an equilibrium relationship in the long-run. Using the VECM developed by Johansen (1991), this long-run relationship may be examined.

Johansen's (1991) procedure requires the usage of variables that are non-stationary with a unit root. Therefore, before proceeding with the analysis, it is imperative to ascertain whether the variables are integrated of order one, I(1), at levels and of order zero, I(0), at first differences. For cointegration to exist between non-stationary variables, at least two variables of all those included in the cointegration system have to be integrated of order one (Hansen & Juselius, 2002). Accordingly, the Augmented Dickey-Fuller (ADF) and Phillips-Peron (PP) unit root tests will be performed to determine if this condition is met (see Dickey & Fuller, 1981; Phillips & Perron, 1988). Following the unit root tests, the VECM will be estimated.

Johansen (1991) developed the VECM as:

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

$where$:

$\Delta = \text{First difference notation}$

$Y_t = p \times 1 \; vector \; integrated \; of \; order \; 1$

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

$k = Lag \; structure$

$\in_t = p \times 1 \; Gaussian \; white \; noise \; residual \; vector$

$\text{r}_j = p \times p \; \; matrix \; indicating \; short \; run \; adjustments \; among \; variables \; across \; \text{p} \; equations$
$at \; the \; j_{th} \; lag$

$\alpha = p \times r \; speed \; of \; adjustment$

$\beta = p \times r \; cointegrating \; vectors$

According to Banerjee, Dolado, Galbraith and Hendry (1993), the number of cointegrating vectors identified using the Johansen system of cointegration is sensitive to the number of lags in the VAR model. The lag length selection is also critical to ensure that the residuals from each equation of the VECM are uncorrelated. The appropriate lag length will thus be determined prior to conducting the cointegration analysis. The most general methods of selecting the optimal lag length are the Akaike Information Criterion (AIC), the Schwarz (SC) information criterion and the Hannan-Quinn (HQ) information criterion. This study will make use of the above three methods. Once the appropriate lag length is determined, the study will proceed to determine the existence of any long-run relationships among the variables using the VECM.

The VECM is estimated by regressing the ΔY_t matrix against the lagged differences of ΔY_t and ΔY_{t-k} and determining the rank of $\pi = \alpha\beta'$. The eigenvectors in β' are estimated from the canonical correlations of the set of residuals from the regression equations. To determine the rank of π, which gives the order of cointegration (r), the eigenvalues of $\pi, \lambda_{i,}$ must be calculated. The order of cointegration is tested for using λ_{trace} and λ_{max} test statistics.

These statistics are given by the following equations:

$$\lambda_{trace} = -T \sum_{i=r-1}^{p} \ln(1 - \lambda_1) \quad (2)$$

$$\lambda_{max} = -T \ln(1 - \lambda_{r+1}) \quad (3)$$

$where$:

$\lambda_i = Estimated\ values\ of\ the\ eigenvalues$

$T = Number\ of\ usable\ observations$

The maximum number of cointegrating relationships will be based on the λ_{trace} tests. The λ_{max} test is used to test specific alternative hypotheses. Models where π has a full rank imply that Y_t is stationary and not I(1) as assumed under the VECM. These models will be rejected as there will be no error-correction (Maysami & Koh, 2000).

Once the order of cointegration has been determined, it is then necessary to select and analyse the relevant cointegrating vector and speed of adjustment coefficients. Where π does not have a full rank and multiple cointegrating vectors are present, the first eigenvalue will be chosen. Since this study uses the natural logarithm of the JSE ALSI as the dependent variable, β' will be normalised with respect to the coefficient of the JSE ALSI.

The Likelihood Ratio (LR) test developed by Johansen (1991) will subsequently be performed on the parameters of the cointegrating vector. This is critical as it identifies the macroeconomic variables that are significant in the long-run relationship. The null hypothesis can be expressed as:

$$H_0: \beta = H_\phi \quad (4)$$

$where$:

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

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

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

Variables will also be tested for weak exogeneity by imposing linear restrictions on the speed of adjustment coefficients. The LR test will be utilised to assess if these coefficients are statistically significant.

The LR test statistic is given by the following equation and follows a χ^2distribution with $r \times (p + 1 - s)$ degrees of freedom:

$$LR = T \sum_{i=1}^{r} ln \frac{1-\lambda_{H,i}}{1-\lambda_i} \quad (5)$$

$where$:

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

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

Lastly, the short-run dynamics of the VECM will be analysed using impulse response functions and a variance decomposition of the JSE. Impulse response functions trace the response of the stock market to a one-time positive standard deviation shock in the economic variables. Variance decompositions measure each shock's contribution to the forecast error variance of the JSE. Both computations are valuable in examining how shocks to economic variables are received in a system.

5 RESULTS

The descriptive statistics of the level data are presented in Table 2 below.

Table 2: Descriptive statistics of variables in levels

	Mean	**Standard deviation**	**Minimum**	**Maximum**
Variables in levels				
JSE	7.0611	0.0923	5.8876	8.3799
CPI	1.7197	0.0732	-0.8440	2.5953
EX	1.8586	0.0340	1.2467	2.4845
GDP	14.0769	0.0218	13.7721	14.3723
GP	8.0888	0.0837	7.2103	9.5940
IP	4.5551	0.0116	4.3241	4.7397
IR	2.2803	0.0403	1.6092	3.0141
LGB	2.3826	0.0320	1.9257	2.8576
M3	13.5722	0.0856	12.3197	14.6669
OP	5.4677	0.1037	3.8641	7.0090

5.1 UNIT ROOT TESTS

For cointegration to exist among non-stationary variables, at least two variables must be I(1). Hence, all variables are tested for a unit root to determine if this requirement is satisfied. ADF and PP tests are run on levels and first differences of the variables; the results are displayed in Table 3.

Table 3: Augmented Dickey-Fuller and Phillips-Perron tests for presence of a unit root

Variables	ADF test t-stat and (p-value)	PP test t-stat and (p-value)
JSE	-0.1376	-0.1278
	(0.9401)	(0.9419)
ΔJSE_t	-8.3426***	-8.3375***
	(0.0000)	(0.0000)
CPI	-4.4715***	-2.9324**
	(0.0005)	(0.0464)
ΔCPI_t	-5.9725***	-4.4306***
	(0.0000)	(0.0006)
EX	-1.8497	-1.8986
	(0.3541)	(0.3314)
ΔEX_t	-7.7652***	-7.7785***
	(0.0000)	(0.0000)
GDP	-0.6393	-0.5684
	(0.8546)	(0.8706)
ΔGDP_t	-3.9879***	-4.0891***
	(0.0025)	(0.0018)
GP	0.7212	0.7212
	(0.9919)	(0.9919)
ΔGP_t	-8.1192***	-8.1198***
	(0.0000)	(0.0000)
IP	-2.0908	-2.0731
	(0.2490)	(0.2560)
ΔIP_t	-7.7071***	-7.7587***
	(0.0000)	(0.0000)
IR	-1.0995	-0.8208
	(0.7122)	(0.8073)
ΔIR_t	-6.2656***	-6.2304***
	(0.0000)	(0.0000)
LGB	-0.6637	-0.4451
	(0.8488)	(0.8951)
ΔLGB_t	-8.9748***	-9.5843***
	(0.0000)	(0.0000)
M3	-1.9652	-1.3996
	(0.3014)	(0.5782)
$\Delta M3_t$	-6.3916***	-6.7116***
	(0.0000)	(0.0000)
OP	-1.1304	-1.0435
	(0.6999)	(0.7338)
ΔOP_t	-9.4478***	-9.6079***
	(0.0000)	(0.0000)

Notes: *** denotes significance at the 1% significance level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

Table 3 indicates that CPI is a stationary series. The remaining variables are all I(1) at the 1% level thus the requirement for the existence of cointegration is met. The results of the unit root tests seem almost too suitable since according to Perron (1989), most macroeconomic data do not contain a unit root. It is important to note that the ADF and PP test statistics are biased towards accepting the null hypothesis of a unit root when structural breaks are disregarded. Furthermore, higher frequency data yields more favourable unit root results. While structural breaks are disregarded, this study uses less frequent (quarterly) data. Moreover there is stronger evidence of cointegration using quarterly data than data of a higher frequency (Kasa, 1992).

5.2 VECM

In order to proceed with the VECM, a long-run equilibrium relationship or cointegration among the variables must exist. The Johansen approach to testing for cointegration is highly sensitive to the number of lags in the model. This study determines the appropriate lag length in the systematic manner outlined in the literature. A VAR model is run on the variables in levels. The appropriate lag length for the VAR model is that which minimises the AIC, SC and HQ information criterion. For cointegration, this lag length is reduced by one as the cointegration test first differences the series. The results of the VAR lag order selection criteria are displayed in Table 55 of Appendix C. The appropriate lag length for the cointegration test is four since two out of the three criterions point to a lag length of five for the VAR model.

The purpose of the cointegration test is to establish whether a long-run equilibrium relationship exists among the variables. The number of significant cointegrating relationships is determined using the maximum likelihood based λ_{trace} and λ_{max} statistics.

Table 4 presents the λ_{trace} and λ_{max} statistics assuming four lags. The results of the λ_{trace} test indicate that there are 10 cointegrating equations at the 5% level of significance while λ_{max} statistics indicate that there are 7 cointegrating equations. Johansen (1996) suggests that the λ_{trace} statistics are more powerful than the λ_{max} statistics as the λ_{max} statistics are not asymptotically correct. Therefore the study concludes that there are 10 cointegrating equations ($r = 10$). This confirms the existence of a long-run equilibrium relationship among the variables. With this result, the study proceeds to specify the long-run dynamic equation using the VECM.

Table 4: Cointegration test results

H_o	λ_{trace}	$CV_{(trace, 5\%)}$	λ_{max}	$CV_{(max, 5\%)}$
r = 0	684.6293*	239.2354	179.7237*	64.50472
r ≤ 1	504.9055*	197.3709	131.2473*	58.43354
r ≤ 2	373.6583*	159.5297	105.7818*	52.36261
r ≤ 3	267.8765*	125.6154	100.7942*	46.23142
r ≤ 4	167.0823*	95.75366	52.90350*	40.07757
r ≤ 5	114.1788*	69.81889	34.90091*	33.87687
r ≤ 6	79.27785*	47.85613	33.78927*	27.58434
r ≤ 7	45.48858*	29.79707	20.04125	21.13162
r ≤ 8	25.44733*	15.49471	17.31525*	14.26460
r ≤ 9	8.132080*	3.841466	8.132080*	3.841466

Notes: The critical values for the above statistics are obtained from MacKinnon–Haug–Michelis (1999). *r* denotes the number of cointegrating relationships. * denotes the rejection of the hypothesis at the 5% level of significance. The optimal lag length of the VAR for testing the cointegration is two.

In the presence of multiple cointegrating vectors, Johansen and Juselius (1990) suggest that the first eigenvector based on the largest eigenvalue is the most useful as it is correlated the most with the stationary part of the model. Hence, the analysis of this study is premised on the cointegrating vector represented by the largest eigenvalue. After normalising with respect to the JSE, the cointegrating vector is given by:

$$\beta_1' = [1.00, -0.169, -0.329, -14.393, 0.369, 1.111, 0.200, -1.275, 1.306, 0.417]$$

The cointegrating vector yields a restricted long-run relationship that may be expressed as:

$$JSE_t = 170.984 + 0.169CPI_t + 0.329EX_t + 14.393GDP_t - 0.369GP_t - 1.111IP_t - 0.200IR_t + 1.275LGB_t - 1.306M3_t - 0.417OP_t$$

The coefficients of CPI, EX, GDP, GP, IP, IR, LGB, M3 and OP can be viewed as long-term elasticity measures. Table 5 presents these coefficients with their corresponding t-statistics and standard errors as if all variables, including the JSE, were on the same side of the equation. Thus, each economic variable’s coefficient in Table 5 should be interpreted as having an effect on the JSE that is in opposition to its corresponding sign. Accordingly, the coefficients presented in Table 5 suggest that the JSE has positive, long-run relationships with the Rand/Dollar exchange rate, GDP, inflation and the long-term interest rate. By contrast, the results indicate that the gold price, industrial production, the short-term interest rate, money supply and the oil price form negative relationships with the South African stock market in the long-run.

Table 5: Vector Error Correction Model: Long-run coefficients

Variable	Coefficient	Standard Error	t-statistic
JSE	1.0000		
CPI	-0.1689	0.0134	-12.6131***
EX	-0.3285	0.0598	-5.4948***
GDP	-14.3927	1.1704	-12.2971***
GP	0.3690	0.0472	7.8128***
IP	1.1111	0.2764	4.0202***
IR	0.2000	0.0392	5.1035***
LGB	-1.2753	0.0887	-15.0439***
M3	1.3055	0.2195	5.9514***
OP	0.4174	0.0543	7.6928***

Notes: *** denotes significance at the 1% significance level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

Having estimated the VECM, it is necessary to identify the factors that contribute significantly to the long-run equilibrium relationship. The significance of each economic factor is tested for using the LR test proposed by Johansen (1991). The LR test involves imposing linear restrictions on the coefficients such that they equal zero. Table 6 displays the resulting chi-square statistics and their corresponding p-values for each of the coefficients. The findings indicate that all nine economic factors contribute significantly to the long-run relationship at the 1% level.

Table 6: Likelihood Ratio test results: Restrictions on long-run coefficients

Restriction	Chi-square statistic	p-value
$\beta_{CPI} = 0$	39.0952	0.0000***
$\beta_{EX} = 0$	13.7681	0.0002***
$\beta_{GDP} = 0$	35.1968	0.0000***
$\beta_{GP} = 0$	35.2936	0.0000***
$\beta_{IP} = 0$	9.3546	0.0022***
$\beta_{IR} = 0$	17.1728	0.0000***
$\beta_{LGB} = 0$	42.6530	0.0000***
$\beta_{M3} = 0$	13.1363	0.0003***
$\beta_{OP} = 0$	13.5616	0.0002***

Notes: *** denotes significance at the 1% significance level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

An important feature of the VECM is that all variables in the cointegrated system are treated as endogenous. Variables interact with each other when the system has deviated from its long-run state to return the system to its equilibrium. This interaction is facilitated by the speed of adjustment coefficients in the error correction term. The VECM provides coefficients that correspond to the speeds of adjustment towards a long-run equilibrium of ΔJSE, ΔCPI, ΔEX, ΔGDP, ΔGP,

ΔIP, ΔIR, ΔLGB, $\Delta M3$ and ΔOP. Table 7 displays the estimated coefficients with their corresponding t-statistics and standard errors.

Table 7: Vector Error Correction Model: Speed of adjustment coefficients

Variable	Coefficient	Standard Error	t-statistic
ΔJSE	-0.1607	0.4362	-0.3684
ΔCPI	1.403117	0.80497	1.74307*
ΔEX	0.174360	0.35043	0.49756
ΔGDP	0.030849	0.01600	1.92846*
ΔGP	-0.391283	0.35103	-1.11466
ΔIP	0.010969	0.11948	0.09181
ΔIR	0.701527	0.30054	2.33422**
ΔLGB	0.202598	0.23055	0.87875
ΔM3	0.148915	0.06865	2.16925**
ΔOP	-1.088043	0.73462	-1.48109

Notes: *** denotes significance at the 1% significance level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

The speed of adjustment parameter referring to ΔJSE is $\alpha_{JSE} = -0.1607$. The t-statistic corresponding to α_{JSE} is -0.3684 rendering the error correction mechanism insignificant even though a linear combination of all the variables is cointegrated. This result has important implications on market efficiency; it indicates that the South African stock market is yet to be efficient in terms of auto correction.

If the restriction $\alpha = 0$ holds, the corresponding variable is said to be weakly exogenous to the system. An important implication of weakly exogenous variables is that it causes its corresponding cointegrating vectors to be disregarded within the VECM. Therefore inferences on cointegrating vectors may be performed without loss of generality using a partial model that excludes the weakly exogenous variables. Variables are therefore tested for weak exogeneity by imposing restrictions on the speed of adjustment coefficients such that $\alpha = 0$. The LR test is used to determine whether the restriction can be rejected or not. The results are displayed in Table 8. The study finds that CPI, GDP, IR and M3 adjust to deviations from the long-run equilibrium while EX, GP, IP, LGB and OP are weakly exogenous to the system. Consequently, the VECM is re-estimated using only JSE, CPI, GDP, IR and M3.

Table 8: Likelihood Ratio test results: Restrictions on speed of adjustment coefficients

Restriction	Chi-square statistic	p-value
$\alpha_{CPI} = 0$	6.4701	0.0109**
$\alpha_{EX} = 0$	0.5759	0.4479
$\alpha_{GDP} = 0$	7.0237	0.0080***
$\alpha_{GP} = 0$	2.6386	0.1043
$\alpha_{IP} = 0$	0.0159	0.8995
$\alpha_{IR} = 0$	11.1535	0.0008***
$\alpha_{LGB} = 0$	1.6083	0.2047
$\alpha_{M3} = 0$	7.1811	0.0074***
$\alpha_{OP} = 0$	3.6048	0.0576

Notes: *** denotes significance at the 1% significance level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

5.3 A RE-ESTIMATED VECM

This section will examine the long-run equilibrium relationship between the JSE, and CPI, GDP, IR and M3. The study has already established that GDP, IR and M3 are I(1) therefore the requirement for the existence of cointegration among the variables is met. Before proceeding with the test for cointegration, the optimal lag structure is determined using the same procedure employed in section 5.2. The results of the VAR lag order selection are displayed in Table 56 of Appendix C. Since the AIC and HQ information criterion point to a lag order of two for the VAR model, it is optimal to proceed with the cointegration test using a single lag.

The cointegration test is run to establish whether a long-run equilibrium relationship exists among the four variables and the JSE. Table 9 presents the λ_{trace} and λ_{max} statistics assuming one lag. The λ_{trace} statistics indicate that there are two cointegrating equations at the 5% level of significance while the λ_{max} statistics indicate that there is one cointegrating equation. These results suggest that a long-run equilibrium relationship exists among the variables.

Table 9: Cointegration test results (re-estimated)

H_0	λ_{trace}	$CV_{(trace, 5\%)}$	λ_{max}	$CV_{(max, 5\%)}$
r = 0	93.07133*	69.81889	42.14684*	33.87687
r ≤ 1	50.92449*	47.85613	23.04341	27.58434
r ≤ 2	27.88108	29.79707	17.33517	21.13162
r ≤ 3	10.54591	15.49471	9.152821	14.26460
r ≤ 4	1.393087	3.841466	1.393087	3.841466

Notes: The critical values for the above statistics are obtained from MacKinnon–Haug–Michelis (1999). *r* denotes the number of cointegrating relationships. * denotes the rejection of the hypothesis at the 5% level of significance. The optimal lag length of the VAR for testing the cointegration is two.

Given the existence of cointegration, the VECM is re-estimated. The long-run cointegrating vector corresponding to the highest eigenvalue is given by:

$$\beta_1' = [1.00, -0.150, -8.932, -0.195, 1.124]$$

Hence, the restricted long-run relationship may be expressed as:

$$JSE_t = 104.124 + 0.150CPI_t + 8.932GDP_t + 0.195IR_t - 1.124M3_t$$

Table 10 presents the above coefficients with their corresponding t-statistics and standard errors as if all variables, including the JSE, were on the same side of the equation. Thus, each economic variable's coefficient in Table 10 should be interpreted as having an effect on the JSE that is in opposition to its corresponding sign. Consistent with financial theory, stock prices are positively related to GDP. However, contrary to popular expectations, the South African stock market has a positive relationship with inflation and the short-term interest rate, and a negative relation with the money supply. It is interesting to note that the relationship between stock prices and the short-term interest rate changes from negative, in the initial VECM, to positive once the model is re-estimated.

Table 10: Re-estimated Vector Error Correction Model: Long-run coefficients

Variable	Coefficient	Standard Error	t-statistic
JSE	1.0000		
CPI	-0.14962	0.03783	-3.95470***
GDP	-8.932197	1.43440	-6.22714***
IR	-0.194976	0.11423	-1.70682*
M3	1.124032	0.34715	3.23792***

Notes: *** denotes significance at the 1% significance level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

The significance of each economic factor is tested for using the LR test suggested by Johansen (1991). Linear restrictions are imposed on each coefficient such that $\beta = 0$. Table 11 displays the resulting chi-square statistics and their corresponding p-values. The findings suggest that CPI, GDP and M3 have significant effects on the South African stock market in the long-run. Interestingly, the short-term interest rate emerged as an insignificant factor even though it proved significant in the initial VECM. The short-term interest rate's loss of power may be the result of possible multicollinearity among the variables.

Table 11: LR test results: Restrictions on re-estimated long-run coefficients

Restriction	Chi-square statistic	p-value
$\beta_{CPI} = 0$	6.2044	0.0127**
$\beta_{GDP} = 0$	8.7400	0.0031***
$\beta_{IR} = 0$	1.5113	0.2189
$\beta_{M3} = 0$	4.2869	0.0384**

Notes: *** denotes significance at the 1% significance level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

The error correction mechanism of the model is subsequently analysed. Table 12 displays the estimated speed of adjustment coefficients of $\Delta JSE, \Delta CPI, \Delta GDP, \Delta IR$ and $\Delta M3$ with their corresponding t-statistics and standard errors. The t-statistic corresponding to ΔJSE is 0.572 rendering the error correction mechanism insignificant even though a linear combination of all the variables is cointegrated. This finding is consistent with the results of the initial VECM; the South African stock market appears to be inefficient in terms of auto correction.

Table 12: Re-estimated Vector Error Correction Model: Speed of adjustment coefficients

Variable	Coefficient	Standard Error	t-statistic
∆JSE	0.056477	0.09871	0.57213
∆CPI	1.172305	0.26970	4.34664***
∆GDP	0.014983	0.00419	3.57496***
∆IR	0.284555	0.08522	3.33894***
∆M3	-0.013197	0.01971	-0.66939

Notes: *** denotes significance at the 1% significance level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

Variables are tested for weak exogeneity by imposing restrictions on the speed of adjustment coefficients such that $\alpha = 0$. The restriction is rejected for all variables (see Table 13) thus confirming that all four variables adjust to deviations from the long-run equilibrium.

Table 13: LR results: Restrictions on re-estimated speed of adjustment coefficients

Restriction	Chi-square statistic	p-value
$\alpha_{CPI} = 0$	9.6538	0.0019***
$\alpha_{GDP} = 0$	11.3819	0.0007***
$\alpha_{IR} = 0$	6.9727	0.0083***
$\alpha_{M3} = 0$	6.4701	0.0110**

Notes: *** denotes significance at the 1% significance level, ** denotes significance at the 5% level and * denotes significance at the 10% level.

5.4 IMPULSE RESPONSES

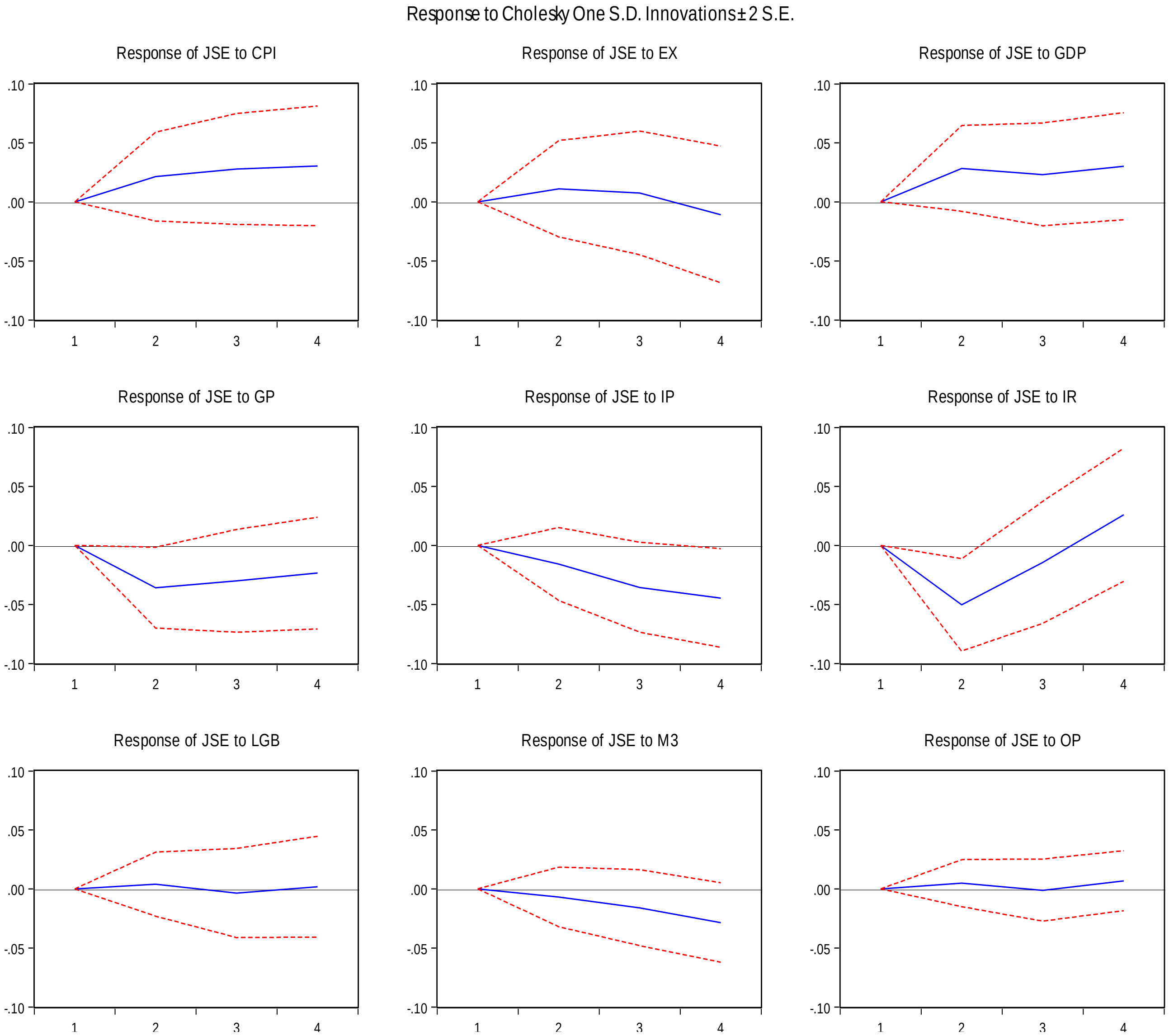
Thus far, the study has focused on determining the long-run equilibrium relationship between the JSE and pre-selected economic variables. This section will address how the variables interact in the short-run (one year) by analysing the impulse response functions of the JSE. An impulse response function (IRF) traces the response of the stock market to a one-time positive standard deviation shock in the economic variables. This provides insight on the sign, speed and persistence of the South African stock market's short-run movement to innovations in the candidate variables. The speed at which the stock market responds to volatility in the economic factors can be interpreted as a measure of its efficiency.

Naka and Tufte (1997) consider two methods for deriving IRFs: A VAR model in levels with one lag (the conventional method) and an equivalent VECM in which the parameters of the cointegrating vector are constrained. The authors conclude that for long horizons, the unrestricted VAR is deficient in its ability to produce sensible responses; the imposition of constraints on cointegrating vectors appears to be essential for reasonable IRFs. However, over shorter horizons, the two methods produce almost identical IRFs. As this section is concerned with the short-run interactions among the variables, either method suffices in producing reasonable IRFs. This study opts for the conventional method for two reasons: First, the estimation of a VAR is simpler than the estimation of a VECM. Secondly, obtaining IRFs from a VECM is a complicated procedure in most computer packages.

Figure 2 illustrates the response of the JSE to a one-tine standard deviation shock on all economic variables over four quarters. It is evident that stock prices react primarily to shocks in CPI, GDP, GP, IP and IR while innovations in EX and M3 seem to generate less of a response. Interestingly, it appears that the JSE is hardly affected by shocks to the long-term interest rate and the oil price.

The IRF indicates that stock prices increase following inflation and GDP shocks until the second quarter after which the JSE stabilises. Similarly, the JSE's negative response to a shock in the price of gold stabilises after the second quarter. The response of the JSE to an innovation in industrial production is consistently negative over the one year horizon. An innovation in the money supply produces a similar response but of a smaller magnitude. The JSE responds interestingly to a shock in the short-term interest rate; stock prices decrease for two quarters after which the relationship becomes positive. The positive relationship viewed after the second quarter lends support to the finding of the re-estimated VECM; stock prices are positively (though insignificantly) related to the short-term interest rate in the long-run.

Figure 2: Impulse responses of the JSE



5.5 VARIANCE DECOMPOSITION

Having established the direction and speed at which the JSE moves in response to innovations in economic factors, a natural question arises: what proportion of stock market volatility can be explained by the volatility in each of the economic variables? To address this question, the variance decomposition of the JSE is analysed. The variance decomposition function provides information on the power each economic variable has in explaining stock market volatility. Additionally, the function identifies the proportion of the movement in the stock market that is due to the JSE's own volatility. Empirical literature suggests that most of the Forecast Error Variance (FEV) of a series is explained by its own volatility (see Lamba & Otchere, 2001; Chinzara & Aziakpono, 2009). Therefore it is anticipated that past stock market volatility explains current volatility better than innovations in any economic variable.

The results of the variance decomposition are reported in Table 14. Consistent with the existing literature, the JSE's past volatility explains the greatest proportion of its current volatility over all four quarters. However, its explanatory power decreases with time. With respect to the explanatory power of the economic variables, the findings of the variance decomposition seem to reinforce the results of the impulse response analysis. The long-term government bond rate and oil price jointly account for a maximum of only 0.38% of the JSE's volatility. In the second quarter, the variables with the greatest explanatory power are the short-term interest rate, GDP and the gold price. The explanatory powers of inflation, the money supply and industrial production are relatively small in the second quarter however their power increases consistently with time. By direct contrast, the short-term interest rate consistently loses its power over time. This finding supports the results of the re-estimated VECM i.e. the short-term interest rate plays an insignificant role on the South African stock market in the long-run.

Table 14: Variance decomposition of the JSE

Period	S.E.	JSE	CPI	EX	GDP	GP	IP	IR	LGB	M3	OP
1	0.10	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.12	64.86	2.90	0.77	5.12	8.17	1.59	16.06	0.10	0.29	0.15
3	0.11	53.48	5.98	0.88	6.54	10.67	7.38	13.35	0.14	1.46	0.12
4	0.12	42.11	8.01	1.10	8.37	10.19	13.03	12.69	0.12	4.12	0.27

6 DISCUSSION OF RESULTS

The empirical results of this study indicate that in the long-run, the JSE has significant positive relationships with GDP and inflation and a significant negative relationship with the money supply. The findings also suggest that the JSE and the short-term interest rate have a positive relationship in the long-run, however this relationship is insignificant. This section will discuss and analyse the mechanics of these relationships.

The significant positive relationship between the JSE and GDP is consistent with economic theory and most international studies; it is the direction of causality that remains debatable. In either scenario, the linkages are simple and intuitive. It can be argued that GDP affects the future cash flows of the firm and through this transmission, GDP leads stock prices. However, assuming markets are efficient, the stock market should contain information on future economic output, not the other way around. The question on causality has not been formally addressed in this paper, however, the results from the impulse response analysis confirm that GDP, at least somewhat, leads stock prices in South Africa. GDP growth is a popular measure used to gauge the health of an economy. Strong GDP growth therefore encourages investors to commit more of their capital to the stock market in an attempt to realise greater stock returns. Indeed, many investors believe that stock indices move in the same direction as the real economy. While counterclaims to this sentiment exist, the existence of the sentiment itself plays an influential role in the level of money that is invested in the stock market at a given time. In the case of the South African stock market, GDP appears to be the most influential of the candidate economic factors; the long-run cointegrating vectors produced by both the initial and re-estimated VECM assign the largest coefficients to GDP. The result is also supportive of the findings of Jefferis and Okeahalam (2000) who analysed the JSE between 1985 and 1995; clearly the relationship between the JSE and GDP, and its significance, has been consistent in both Apartheid and post-Apartheid South Africa.

Although insignificant, the results indicate the existence of a positive long-run relationship between the short-term interest rate and stock prices. This finding opposes the commonly hypothesised negative relation postulated by most financial analysts. The theoretical basis for the conventional prediction is widely discussed in the literature and has received little dispute. It is based on the view that a decrease in interest rates will result in higher future profits, and thus higher stock prices, as borrowing costs of firms will decrease. Additionally, lower interest rates encourage the transfer of capital from the bond market to the equity market, resulting in an increased demand for stocks and consequently, increased stock prices. These predictions are almost certain when shocks to interest rates are observed in isolation. However, if interest rates decline at a time when there is reduced demand for firms' products, sales could decline and the aggregate effects on stock prices become more difficult to predict; depending on the effects of lower borrowing costs and reduced sales, future profits could decrease causing stock prices to decline. Furthermore, lower interest rates do not necessarily result in greater future profits unless total costs decline; the possibility of a simultaneous increase in other input costs is real and in such a case, total costs may increase.

The positive relationship between interest rates and the JSE found in this study can be explained by examining both interest rate changes occurring in the sample period and the prevailing market conditions. Between 1994 and 2012, South Africa experienced the effects of two recessions: the

Asian crisis (1997-1999) and the Great Recession (2007-2009). These periods witnessed dramatic decreases in the short-term interest rate (see Figure 3), the aggregate demand for goods and services and the demand for equities. Additionally, the price of oil increased steadily throughout most of the sample period (see Figure 4). Rising oil prices often cause other input costs to grow as well. Therefore, while the short-term interest rate may have decreased and lowered borrowing costs for firms, projected profits may have actually decreased due to decreased aggregate demand and increased input costs. While the JSE and the short-term interest rate are positively related in the long-run, it is important to note that in the short-run, an opposite relation is displayed. The difference in the effects of interest rate changes in the short-run and long-run represents a possible area for further research.

Figure 3: Short-term interest rate (1994-2012)

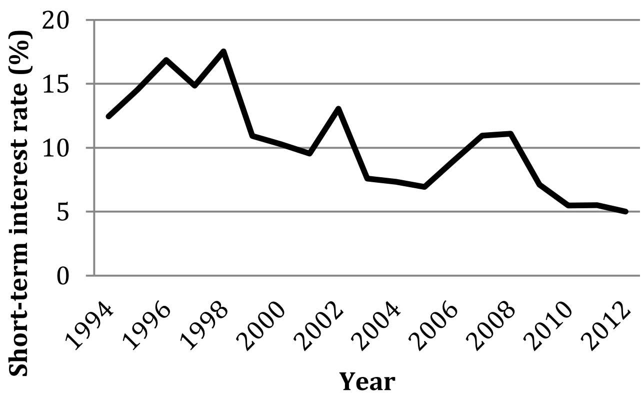
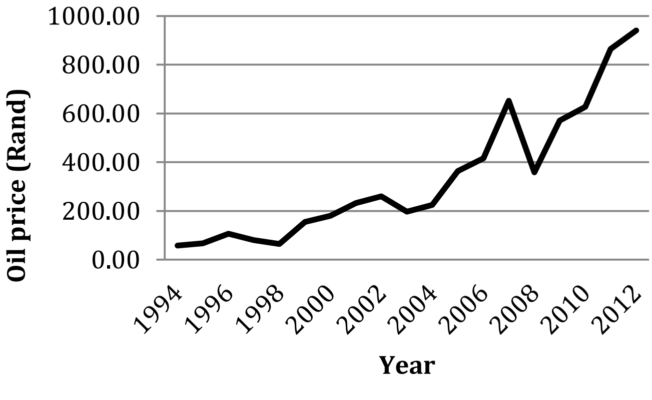


Figure 4: Oil price (1994-2012)



The negative relationship between the money supply and stock prices found in this study requires deeper analysis. Most financial analysts anticipate a positive relationship between the variables. This hypothesis relies on two assumptions: there is a negative causal relationship between money supply and interest rates and a similarly negative relationship between interest rates and stock prices. Therefore, a logical analysis of the negative relationship between the JSE and the money supply, found in this study, must begin with a critical discussion on the assumptions underlying the commonly hypothesised positive relationship. This discussion must be made in the context of the South African market during the sample period.

The assumed negative relationship between money supply and interest rates is based on the short-term liquidity effect. The liquidity effect states that increases in the money supply creates excess supplies of money at existing levels of income, interest rates and prices. The demand for money is a decreasing function of nominal interest rates, which represents the opportunity cost of holding cash. Therefore, it follows that an increase in the supply of money must cause interest rates to decrease to maintain the money market equilibrium (Alatiqi & Fazel, 2008). However, this will only occur if, at the time of the increase in money supply, the money demand curve shifts left or does not shift at all; if there are simultaneous rightward shifts in the money supply and money demand curves, the new equilibrium interest rate may be higher than the old equilibrium rate. This scenario is not unlikely, especially in markets that are experiencing higher price levels and higher real output due to expansionary monetary policy. Clearly, the assumed negative relationship between money supply and interest rates does not always reflect the reality. A positive relationship between the variables is even implied in interest rate theory. The Fisher equation describes the nominal interest rate as the sum of the real interest rate and the expected rate of inflation. Since expansionary monetary policy is generally expected to be inflationary, increases in the money supply may result in increased measures of expected inflation and consequently, increased nominal interest rates.

The relationship between money supply and interest rates in South Africa falls outside the scope of this study. However, even if the possibility of a positive relationship between these variables in South Africa is disregarded, the evidence presented in this study directly opposes the second assumption of the stock price and money supply hypothesis; interest rates and stock prices were found to be positively related. In sum, the negative relationship between the money supply and the JSE found in this study is not in itself inconsistent with financial theory; a negative relationship is in fact probable in the context of expansionary monetary policy. Further, the finding is corroborated by evidence of a positive long-run relationship between the JSE and the short-term interest rate.

Lastly, discussion is required with respect to the unanticipated, positive long-run relationship between the JSE and inflation. Financial theory suggests that inflation and stock prices should be negatively related; an increase in inflation translates to higher nominal rates and higher nominal rates are believed to impact stocks negatively. Most previous studies find evidence in line with this theory (see Fama & Schwert, 1977; Geske & Roll, 1983; Chen et al., 1986; Chen, 199l; DeFina, 1991).

A positive relationship between inflation and stock prices, however, is not inconceivable. Increases in inflation directly impact stock prices positively through changes in the price level. In addition, while nominal interest rates may increase with inflation, expected cash flows are likely to increase as well. Thus, the anticipated negative effects of increased interest rates and the positive effects of increased expected cash flows counter each other. Moreover, in developing markets, steady and low measures of inflation stimulate growth in real activity resulting in positive effects on stock prices (Goswami & Jung, 1997). Although South Africa has had a history of high inflation, the introduction of inflation targeting in 1999 has been successful at maintaining a steady and low inflation rate over the last decade. It is plausible that inflation targeting has impacted stock prices positively through its stimulus on real activity, especially given the study's evidence of a highly significant positive relationship between GDP and the JSE. Even if this transmission is deemed to be 'too far removed', the positive relationship between the short-term interest rate and the JSE found in this study actually implies a positive relationship between inflation and the JSE, thus supporting the reliability of this finding.

7 CONCLUSION

Despite the extensive literature on the relationship between economic factors and stock prices, few studies test this relationship in South Africa. Even fewer South African studies utilise the VECM, which represents the standard and more appropriate technique for examining cointegration among financial variables; the VECM enables the analysis of long-run relationships as well as short-run adjustment processes between non-stationary variables. This paper performs an empirical analysis on the long-run equilibrium relationship between economic factors and the JSE using the cointegration procedure outlined by Johansen (1991). As most previous studies on this subject were conducted on pre-1994 data, this study fills the void in the literature by analysing a more relevant, post-Apartheid sample period.

In the spirit of Chen et al. (1986), economic factors were pre-selected. The results of the cointegration analysis and VECM are in conformity with the prevailing literature; using quarterly data between 1994 and 2012, it is found that only a few factors describe the JSE pricing mechanism and a long-run relationship exists between these variables and South African stock returns. The coefficients of the normalised long-run parameter, produced by the VECM, indicate positive long-run relationships between the JSE and inflation, GDP, and the short-term interest rate, and a negative relation between the JSE and the money supply. The positive relationship between the JSE and GDP fits well with existing literature however the remaining relationships oppose conventional theory. After discussing these 'unexpected' relationships in the context of the sample period, the study shows that from a holistic perspective, the relationships produced by the VECM are plausible. While a linear combination of all modeled variables is found to be cointegrated, the t-statistics corresponding to the coefficients of the economic factors imply that only three variables form significant long-run relationships with the JSE at the 5% level. These variables are inflation, GDP and the money supply.

The short-run dynamic system was analysed by examining IRFs and a variance decomposition of the JSE. The results suggest that in the short-run, the JSE responds each quarter to one-time standard deviation innovations in inflation, GDP, the gold price, industrial production and the short-term interest rate. These factors, however, account for a small proportion of the short-run movement in the JSE. The most influential factor in each quarter appears to be the JSE's own performance in the previous quarter. This finding is in line with existing literature indicating that most of the FEV of a series is explained by its own volatility.

The results of this study are directly comparable with the findings of Jefferis and Okeahalam (2000), who analysed the relationship between several economic factors and the JSE using cointegration techniques. Examining quarterly data in a period when the JSE was crippled by the Apartheid system (1985-1995), the authors found 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. This study therefore reveals that the South African stock market's relationship with GDP has not changed post-Apartheid; the JSE remains significantly cointegrated with the quarterly measure of GDP. However it appears that the JSE's long-run sensitivities to the exchange rate and the long-term interest are no longer valid in the post-Apartheid market. Instead, the money supply and inflation have gained significance.

From the perspective of asset pricing, the existence of cointegration reported in this study confirms the notion postulated by Fama (1981): stock prices are grounded in macroeconomic fundamentals. This result has important implications on the applicability of asset pricing models in South Africa.

Specifically, the study rejects the CAPM in favour of the multi-factor APT, identifying inflation, GDP and the money supply as priced risk factors. However, given the low R-squared of the VECM, there may be other macroeconomic variables of statistical significance that still remain unidentified.

8 RECOMMENDATIONS FOR FURTHER RESEARCH

Based on the abovementioned findings, three recommendations are made for further research: First, the relationship between the JSE and global economic factors should be analysed as markets are becoming more integrated. Second, researchers may examine the effects of qualitative variables (such as political events, changing legislation and economic agreements) on the JSE as these are likely to affect investor sentiment. Lastly, it would be interesting to test for the existence of asymmetry in the way different stock portfolios react to the same economic variables.

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10 APPENDICES

10.1 APPENDIX A: ADF TEST RESULTS

Table 15: ADF test on CPI (level)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.471460	0.0005
Test critical values:	1% level	-3.522887	
	5% level	-2.901779	
	10% level	-2.588280	

Table 16: ADF test on CPI (first difference)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.972489	0.0000
Test critical values:	1% level	-3.524233	
	5% level	-2.902358	
	10% level	-2.588587	

Table 17: ADF test on EX (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		-1.849682	0.3541
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 18: ADF test on EX (first difference)

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		-7.765169	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 19: ADF test on GDP (level)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.639278	0.8546
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 20: ADF test on GDP (first difference)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.987877	0.0025
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 21: ADF test on GP (level)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.721177	0.9919
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 22: ADF test on GP (first difference)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.119231	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 23: ADF test on IP (level)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.090780	0.2490
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 24: ADF test on IP (first difference)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.707127	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 25: ADF test on IR (level)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.099498	0.7122
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 26: ADF test on IR (first difference)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.265616	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 27: ADF test on JSE (level)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.137600	0.9408
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 28: ADF test on JSE (first difference)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.342574	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 29: ADF test on LGB (level)

Null Hypothesis: LGB has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.663717	0.8488
Test critical values:	1% level	-3.521579	
	5% level	-2.901217	
	10% level	-2.587981	

Table 30: ADF test on LGB (first difference)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.974845	0.0000
Test critical values:	1% level	-3.521579	
	5% level	-2.901217	
	10% level	-2.587981	

Table 31: ADF test on M3 (level)

Null Hypothesis: M3 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.965188	0.3014
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 32: ADF test on M3 (first difference)

Null Hypothesis: D(M3) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.391622	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 33: ADF test on OP (level)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.130406	0.6999
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 34: ADF test on OP (first difference)

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.447764	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

10.2 APPENDIX B: PP TEST RESULTS

Table 35: PP test on CPI (level)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.932414	0.0464
Test critical values:	1% level	-3.521579	
	5% level	-2.901217	
	10% level	-2.587981	

Table 36: PP test on CPI (first difference)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.430638	0.0006
Test critical values:	1% level	-3.522887	
	5% level	-2.901779	
	10% level	-2.588280	

Table 37: PP test on EX (level)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.898608	0.3314
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 38: PP test on EX (first difference)

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		-7.778468	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 39: PP test on GDP (level)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.568370	0.8706
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 40: PP test on GDP (first difference)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.089137	0.0018
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 41: PP test on GP (level)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		0.721177	0.9919
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 42: PP test on GP (first difference)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.119810	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 43: PP test on IP (level)

Null Hypothesis: IP has a unit root
Exogenous: Constant
Bandwidth: 8 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.073070	0.2560
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 44: PP test on IP (first difference)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-7.758718	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 45: PP test on IR (level)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.820823	0.8073
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 46: PP test on IR (first difference)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.230379	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 47: PP test on JSE (level)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.127753	0.9419
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 48: PP test on JSE (first difference)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.337519	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 49: PP test on LGB (level)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.445134	0.8951
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 50: PP test on LGB (level)

Null Hypothesis: D(LGB) has a unit root
Exogenous: Constant
Bandwidth: 21 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-9.584274	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 51: PP test on M3 (level)

Null Hypothesis: M3 has a unit root
Exogenous: Constant
Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.399631	0.5782
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 52: PP test on M3 (first difference)

Null Hypothesis: D(M3) has a unit root
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.711594	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

Table 53: PP test on OP (level)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.043464	0.7338
Test critical values:	1% level	-3.519050	
	5% level	-2.900137	
	10% level	-2.587409	

Table 54: PP test on OP (first difference)

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-9.607894	0.0000
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

10.3 APPENDIX C: LAG LENGTH CRITERIA TESTS

Table 55: VAR lag order selection

VAR Lag Order Selection Criteria
Endogenous variables: JSE IR LGB CPI EX GDP IP M3 GP OP
Exogenous variables: C
Date: 09/23/13 Time: 09:52
Sample: 1994Q1 2013Q1
Included observations: 70

Lag	LogL	LR	FPE	AIC	SC	HQ
0	469.5982	NA	9.38e-19	-13.13138	-12.81016	-13.00379
1	1222.830	1269.734	7.55e-27	-31.79514	-28.26179*	-30.39165
2	1325.049	143.1060	8.36e-27	-31.85853	-25.11305	-29.17914
3	1422.571	108.6678	1.43e-26	-31.78774	-21.83012	-27.83245
4	1569.506	121.7462	1.07e-26	-33.12875	-19.95899	-27.89756
5	1812.102	131.6948*	1.70e-27*	-37.20291*	-20.82101	-30.69582*

* 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

Table 56: VAR lag order selection (re-estimated)

VAR Lag Order Selection Criteria
Endogenous variables: JSE CPI GDP IR M3
Exogenous variables: C
Date: 11/22/13 Time: 13:57
Sample: 1994Q1 2012Q3
Included observations: 70

Lag	LogL	LR	FPE	AIC	SC	HQ
0	141.3028	NA	1.40e-08	-3.894366	-3.733759	-3.830571
1	624.7028	883.9314	2.88e-14	-16.99151	-16.02787*	-16.60874
2	672.1826	80.03746*	1.53e-14*	-17.63379*	-15.86711	-16.93204*
3	690.9442	28.94639	1.88e-14	-17.45555	-14.88584	-16.43483
4	711.9731	29.44049	2.23e-14	-17.34209	-13.96935	-16.00239
5	726.4417	18.18904	3.29e-14	-17.04119	-12.86541	-15.38252

* 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

10.4 APPENDIX D: COINTEGRATION TEST RESULTS

Table 57: Cointegration test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.923271	684.6293	239.2354	0.0000
At most 1 *	0.846639	504.9055	197.3709	0.0001
At most 2 *	0.779348	373.6583	159.5297	0.0000
At most 3 *	0.763053	267.8765	125.6154	0.0000
At most 4 *	0.530348	167.0823	95.75366	0.0000
At most 5 *	0.392610	114.1788	69.81889	0.0000
At most 6 *	0.382887	79.27785	47.85613	0.0000
At most 7 *	0.248965	45.48858	29.79707	0.0004
At most 8 *	0.219141	25.44733	15.49471	0.0012
At most 9 *	0.109678	8.132080	3.841466	0.0044

Trace test indicates 10 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**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 *	0.923271	179.7237	64.50472	0.0000
At most 1 *	0.846639	131.2473	58.43354	0.0000
At most 2 *	0.779348	105.7818	52.36261	0.0000
At most 3 *	0.763053	100.7942	46.23142	0.0000
At most 4 *	0.530348	52.90350	40.07757	0.0011
At most 5 *	0.392610	34.90091	33.87687	0.0376
At most 6 *	0.382887	33.78927	27.58434	0.0070
At most 7	0.248965	20.04125	21.13162	0.0705
At most 8 *	0.219141	17.31525	14.26460	0.0160
At most 9 *	0.109678	8.132080	3.841466	0.0044

Max-eigenvalue test indicates 7 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 58: Cointegration test (re-estimated)

Date: 11/22/13 Time: 14:02
Sample (adjusted): 1994Q3 2012Q3
Included observations: 73 after adjustments
Trend assumption: Linear deterministic trend
Series: JSE CPI GDP IR M3
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.438618	93.07133	69.81889	0.0002
At most 1 *	0.270695	50.92449	47.85613	0.0250
At most 2	0.211378	27.88108	29.79707	0.0819
At most 3	0.117839	10.54591	15.49471	0.2410
At most 4	0.018902	1.393087	3.841466	0.2379

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**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 *	0.438618	42.14684	33.87687	0.0041
At most 1	0.270695	23.04341	27.58434	0.1716
At most 2	0.211378	17.33517	21.13162	0.1568
At most 3	0.117839	9.152821	14.26460	0.2737
At most 4	0.018902	1.393087	3.841466	0.2379

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

1 Cointegrating Equation(s): Log likelihood 675.8213

Normalized cointegrating coefficients (standard error in parentheses)

JSE	CPI	GDP	IR	M3
1.000000	-0.149620	-8.932197	-0.194976	1.124032
	(0.03783)	(1.43440)	(0.11423)	(0.34715)

Adjustment coefficients (standard error in parentheses)

D(JSE)	0.056477
	(0.09871)
D(CPI)	1.172305
	(0.26970)
D(GDP)	0.014983
	(0.00419)
D(IR)	0.284555
	(0.08522)
D(M3)	-0.013197
	(0.01971)