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The impact of macroeconomic variables on industrial shares listed on the Johannesburg Stock Exchange

Kamoto Banda[a], John Henry Hall[a] and Rudra P. Pradhan[b]

[a]Department of Financial Management, Faculty of Economic and Management Sciences, University of Pretoria, Pretoria, South Africa; [b]Vinod Gupta School of Management, Indian Institute of Technology, Kharagpur, India

ABSTRACT
This paper aims to address the absence of research on the relationship between macroeconomic variables (aggregate economic output, inflation, interest rates and exchange rates) and industrial shares in developing countries. The Industrial Index (INDI 25) on the Johannesburg Stock Exchange (JSE) was analysed using data from 1995 to 2017. The results show that inflation has a significant positive relationship with stock prices. However, a negative relationship was found between interest rates and stock prices. In this period, exchange rates had a positive effect on industrial shares, but no relationship was identified between industrial shares and the gross domestic product (GDP).

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Stock price; industrial index; JSE; prime interest rate; exchange rate

1. Introduction

According to Chandra (2009), between 30% and 35% of changes in shareholder value and stock returns can be attributed to the macroeconomic environment. Positive shareholder returns and value creation should be the objective of every firm's management, investors and portfolio managers, so it is important to study the link between macroeconomic variables and stock returns.

Most prior studies on macroeconomic variables and share returns have focused on the broad stock market, and therefore included data from all sectors. Analysing the relationship between macroeconomic variables and share returns using a broad index is indeed informative; however, the overall results do not offer sector-specific information, because the results for each index constituent may differ, due to specific sector fundamentals. In South Africa, the Industrial 25 Index (INDI 25) on the Johannesburg Stock Exchange (JSE) is widely adopted as a benchmark for numerous investment portfolios (Chandra 2009). In addition, many investors on the JSE hold the INDI 25 as a portfolio constituent. The INDI 25 rose by 88% from January 2012 to December 2013, and it outperformed the other large-cap share indices in different sectors. Over the same period, the Resource 10 Index remained unchanged, the Financial 15 Index went up by 52%, and the Top 40 Share Index rose by 44% (Hedley 2014).

A review of the literature on the topic shows that there have been few studies on the impact of South African macroeconomic variables on shareholder returns in a particular

CONTACT John Henry Hall John.Hall@up.ac.za

sector. Some exceptions are the studies by Eita (2012), Junkin (2012), MacFarlane (2011) and Moolman and Du Toit (2005). The main aim of the present paper is, therefore, to undertake a detailed investigation into possible relationships between macroeconomic variables and the industrial sector, more specifically, the INDI 25. Research on the relationship between macroeconomic variables and the INDI 25 is important for four reasons. Firstly, despite a significant amount of research over three decades examining the link between macroeconomic variables and stock market indices, no study has yet been published on the relationship between macroeconomic variables and industrial shares, especially in South Africa's emerging market context. Secondly, the specific set of macroeconomic variables used in this study has not so far been used in any studies. Thirdly, as indicated, INDI 25 has provided the highest returns as a sector on the JSE from 2012 to 2013, suggesting that it is an important investment avenue. Lastly, the present study applies statistical analysis techniques and procedures that have not previously been used in an analysis of this nature. The findings of this study show that for the period under review, inflation, as reflected in the Consumer Price Index (CPI), is significantly positively associated with stock prices. Hence, investors got some compensation for inflation. Interest rates had a negative relationship with industrial shares (similar to the inverse relationship between interest-bearing securities and interest rates). By contrast, exchange rates displayed a positive relation with the INDI 25. There was no relationship between the INDI 25 and the gross domestic product (GDP). Furthermore, two error correction terms were obtained from the vector error correction model (VECM). The first was insignificant and failed to indicate any long-run relationship, but the other was significant, indicating short-term adjustments and the presence of a long-run relationship from GDP, CPI, interest rates and exchange rates to the INDI 25. Moreover, the application of a Granger causality test revealed only univariate causality from the INDI 25 to interest rates.

The remainder of this paper is structured as follows: in Section 2, a review of previous empirical studies is presented; Section 3 describes the data set, and the process and statistical techniques used to analyse the data; Section 4 discusses the findings from the data analyses, and the last section concludes the paper, providing recommendations and suggesting areas for further research.

2. Review of prior empirical studies

Prior research has considered the relationship between the selected macroeconomic variables and share returns in an international and South African context. Relevant studies are discussed below.

2.1. Aggregate economic output and share returns

Fama (1990) tested the link between three macroeconomic and equity returns on the New York Stock Exchange (NYSE) to measure sources of total return variation and to judge the rationality of share prices. Using a multivariate regression analysis to explain the links under investigation, he found that 43% of the total variation in annual returns on the NYSE could be attributed to real activity. Furthermore, his results showed that aggregate economic output was responsible for almost half of the total variation in annual returns on the NYSE.

Using a bivariate Vector Auto Regression (VAR) technique and Impulse Response Function (IRF) methodology, Hassapis and Kalyvitis (2002) investigated the link between real share price changes (price returns) and macroeconomic variables (the consumer price index, the industrial wholesale price index, the industrial output price index and the industrial goods price index) with empirical evidence from the G-7 economies. They found that share price changes in the economies included in their study were strongly positively related to output growth. These findings were consistent with the results of Fama (1990) and Nasseh and Strauss (2000). Kim (2003) as well as Ratanapakorn and Sharma (2007) also found in studies on US data a positive correlation between stock price and industrial production.

Rafique, Amara, and Sultana (2013) examined the impact of four macroeconomic variables (GDP per capita, gross domestic savings, inflation and the discount rate) on the Karachi Stock Exchange (Pakistan), using an Analysis of Variance (ANOVA) model. Their study used time series data spanning 20 years, from 1991 to 2010. Their results indicated that the Pakistani GDP per capita had a significant positive impact on the Karachi Stock Exchange's ALSI.

Thus far, only a few South African studies have focused on the relationship between the GDP and share returns. Using the Johansen cointegration technique, Jefferis and Okeahalam (2000) examined the relationship between share returns and macroeconomic variables in three southern African countries, namely South Africa, Botswana and Zimbabwe. They analysed quarterly time series data for the period from 1985 to 1995. They found that share returns in South Africa were driven mainly by the GDP. More recently, MacFarlane (2011) applied a Johansen cointegration and a Granger causality test to examine whether macroeconomic variables explain future market movements on the JSE. He examined quarterly time series data from 1965 to 2010 and found that the GDP significantly influenced future JSE All Share Index (ALSI) returns and argued that GDP should be used as a predictive tool for South African share market returns.

2.2. Inflation and share returns

Fifield, Power, and Sinclair (2002) investigated the extent to which global and local macroeconomic factors explain share returns in a number of emerging stock markets. They selected their macroeconomic variables using the principal components analysis technique. Variables used in their study were the GDP, inflation, money supply and interest rates (domestic variables). Their selected macroeconomic global variables were world industrial production and world inflation. They developed a regression model to explain the index returns of 13 emerging stock markets from 1987 to 1996. The results indicated that domestic variables were important in explaining stock returns in India and Turkey, but that the addition of the global variables to the domestic variables significantly increased the proportion of variation in returns explained in Greece, Mexico, Portugal and Thailand. In Chile, Hong Kong, Malaysia and the Philippines, neither global inflation rates nor domestic inflation rates were significant in explaining stock returns. Ratanapakorn and Sharma (2007) found a positive relationship between stock prices and inflation in a study on US data.

The relatively high inflation rates of African countries compared to the rest of the world, particularly in the context of fixed nominal interest rates, tend to raise the question of what shelter inflation offers to investors in stock markets of African countries? Michael (2014) studied the relationship between inflation and share market returns using quarterly time series data from January 1992 to December 2010 on the Ghana Stock Exchange (GSE), a stock market in an emerging country. He employed the ADF unit root test and tested for Granger causality using the ECM technique. The findings showed a statistically significant negative relationship between inflation and share returns.

Studies on the link between inflation and share returns in South Africa present conflicting results. Alagidedea and Panagiotidisb (2010) found evidence of a long-run positive relationship between inflation and stock prices for South Africa. This was confirmed by Eita (2012) which used a vector autoregression (VAR) technique and also found that stock market returns and inflation in South Africa are significantly and positively related. The findings of these studies were in contrast to the findings of a study by Junkin (2012). Furthermore, Eita (2012) states that the positive association between the two variables suggests that shares are a hedge against inflation in South Africa.

2.3. Interest rates and share returns

Dinenis and Staikouras (1998) examined the impact of interest rate changes on the share returns of the portfolios of financial institutions in the United Kingdom (UK). They used a two-index model to test the effects of both current and unanticipated interest rate changes and found a significant negative relationship in the UK between share returns and changes in the interest rate (Dinenis and Staikouras 1998). This finding was also confirmed by Kim (2003) and Ratanapakorn and Sharma (2007) with studies on US data. Bernanke and Kuttner (2005) found a relatively strong and consistent response of the stock market to unexpected monetary policy actions; for a 25-basis-point rate cut, an increase in stock prices to the order of 1% was recorded.

Muradoglu, Taskin, and Bigan (2000) investigated the causality relationship between share prices and macroeconomic variables in emerging markets. They followed Mukherjee and Naka (1995) in their selection of the following macroeconomic variables: industrial production, inflation, interest rates and oil prices. The findings indicated a unidirectional relationship, with the direction running from interest rates to share returns. Additionally, interest rates in the emerging markets under study influenced share prices through their effect on future cash flows and the rate at which they are discounted. This conclusion is in line with those of Chen, Roll, and Ross (1986) and Fama (1981).

Giri and Joshi (2017) applied unit root tests, the multivariate co-integration test and the Granger causality test to the Bombay Stock Exchange (BSE) Sensitivity Index and selected macroeconomic indicators (the 91 Days Treasury Bill rate, reserve money, narrow money supply (M1) and broad money supply (M3), the gold price, the oil price, the index of industrial production, the level of foreign exchange reserve and the foreign exchange rate) as their variables, using monthly data from April 1994 to December 2012. They found that the Treasury Bill rate and the share market index was cointegrated. Moreover, the Granger causality test showed a unidirectional causal relationship between the Treasury Bill rate and the BSE Sensitivity Index (Giri and Joshi 2017).

In their study of the relationship between the JSE ALSI and various macroeconomic factors (the GDP, long-term and short-term interest rates, and the gold price), Moolman and Du Toit (2005) found that short-term share price fluctuations are determined by interest rates. They used the Johansen cointegration and ECM techniques to analyse the panel data. Mangani (2009) investigated macroeconomic effects on individual JSE shares on the JSE using weekly data from 1983 to 2002. A GARCH framework was used to investigate the effects of discount rate changes on individual shares. He found that the discount rate was clearly important in describing the dynamics of mean returns. Alam and Uddin (2009) found a negative relationship for both interest rates with share prices and for changes of interest rates and share prices in South Africa. Employing the Johansen cointegration and VECM techniques to analyse time series data from July 1996 to December 2008, (Hancocks 2010) studied the extent to which selected macroeconomic variables influenced share prices on the JSE. The VECM results found that both long- and short-run interest rates influenced share prices. This finding was confirmed by Gupta and Modise (2011) who found that different interest rate variables have short-run predictive ability for share returns for an in-sample test, whilst for an out-of-sample period the change in inflation rate exhibits a very strong predictive ability over the medium- to long-run horizon.

2.4. Foreign exchange rate and share returns

A study by Jorion (1990) investigated the effect of exchange rate changes on US multinational companies. The findings include evidence of a negative relationship between local exchange rates and the share returns of US multinationals. Furthermore, the co-movement between share returns and the value of the dollar was found to be positively related to the percentage of foreign operations of US multinationals. Kim (2003) has also found a negative relationship between share price and exchange rates in a study on 12 years' data of a broad US stock index. However, Ratanapakorn and Sharma (2007) found a positive relationship between stock prices and the exchange rate. To add to the differentiation in results in this regard, Nieh and Lee (2001) found no significant long-run relationship between stock prices and exchange rates in the G-7 countries.

Wickremasinghe (2011) examined the Sri Lankan Stock Exchange and the macro economy. His study addressed several methodological weaknesses in relation to unit root and cointegration tests that prior studies in the same study area had overlooked. He found a causal relationship between the share market and exchange rates. This implies that the share prices on the Sri Lankan share market were able to explain the forecast variance of the US dollar exchange rate. Using a Johansen multivariate cointegration approach and the VECM, Ibrahim and Musah (2014) found that exchange rates explained a significant proportion of the variance error of stock returns in Ghana, and that their effects persisted over a long period. Their study relied on data from September 2000 to September 2010. Furthermore, their Granger causality test could not establish causality from any direction between macroeconomic variables and stock market returns on the Ghana Stock Exchange (Ibrahim and Musah 2014).

The relationship between share prices and the foreign exchange rate has also been studied using South African data. In their study on modelling stock returns on the JSE, Bonga-Bonga and Makakabule (2010) found a significant relationship between exchange rates and share returns. They used a non-linear Smooth Transition Regression (STR) model to account for the smooth asymmetric response of stock returns from economic variables. Using monthly South African data for the period from June 2000 to December 2010, Mlambo, Maredza, and Sibanda (2013) used a GARCH model to assess the effects of exchange rate volatility on the JSE. Their findings confirmed a very weak relationship between currency volatility and the stock market. This weak relationship suggests that the JSE can be marketed as a safe market for foreign investors, although investors and portfolio managers still need to monitor developments between these two variables. Chinzara (2011) found that macroeconomic (inflation to a lesser extent; interest rate and exchange rate to a greater extent) uncertainty significantly influences share market volatility in South Africa. A study by Chinzara and Aziakpono (2009) found volatility and return linkages between the share markets of South African and major world stock markets, especially that of Australia, China and the US as having the highest influence. It falls outside the scope of the present study to include the data from other countries, but it is recommended for further studies to extend the present study.

Prior research on the relationship between macroeconomic variables and stock returns has produced mixed results. A variety of statistical techniques have been employed. However, no study specifically concentrated on industrial shares and very few studies drew on South African data. The present study thus aims to fill this gap in the empirical literature by studying the relationship between a number of macroeconomic variables and the INDI 25 on the JSE. In line with selected prior studies, the macroeconomic variables identified for analysis in the present study were the GDP, the inflation rate, the prime interest rate and the South African rand/US dollar (ZAR/USD) exchange rate. In addition, as the ZAR/USD exchange rate is one of the most volatile in the world, the exchange rate volatility will also be tested and included in the analyses. In the next section, the data and empirical design used to conduct the analyses will be discussed.

3. Empirical design and data

The data for the present study was collected from IRESS, a reliable supplier of quality financial data. The data consist of the quarterly closing values of the JSE's INDI 25 from the third quarter of 1995 to the second quarter of 2017. Quarterly figures for the macroeconomic variables (GDP, CPI, prime interest rate, ZAR/USD exchange rate, and exchange rate volatility) for the same period were also collected.

The empirical design adopted in this paper employed the normality test, correlation analysis, Augmented Dickey–Fuller (ADF) unit root tests, the Johansen cointegration test, the Vector error correction model (VECM) and Granger causality tests in a multivariate framework.

As a starting point, all the data series were tested for normality to identify the nature of the data distribution. The Jarque-Bera (JB) test is the most commonly used normality test, and hence this study adopted that test. We also use correlation analysis to establish the relationship among these chosen variables.

The main aim of this study is to examine the long-run relationship between JSE's INDI 25 and four macroeconomic variables, namely inflation, economic growth, the prime interest rate and the foreign exchange rate/exchange rate volatility. We use cointegration and correlation to examine the long-run relationship among these variables. To ascertain cointegration, it was necessary for the series to be integrated of the same order. To achieve this, we tested for the existence of the unit root in the data series to determine the stationarity and/or nonstationarity of the data. A non-stationary process generates the problem of potentially spurious regression between unrelated variables, so that, in some cases, the regressions produce a high R^2 even where there is no meaningful relation between variables. Although there are many available tests for verifying the presence of a unit root, this study employed the Augmented Dickey–Fuller (ADF) test because of its popularity and wide application. The ADF specification is:

$$\Delta y_t = \alpha_0 + \delta y_{t-1} + \sum_{i=1}^{P} \beta_i \Delta y_{t-i} + \in_t \tag{1}$$

where Δ is the first difference operator, *yt* is the time series to be tested, *α*0 is the intercept, *β*1 is the coefficient of interest in analysing the unit root, *ρ* is the lag order of the autoregressive process and *δ*= *ρ* − 1, and is the white noise error term.

The main idea behind the ADF test is to include enough lagged terms so that the error term is serially uncorrelated. The null and alternative hypotheses were specified as follows:

$H_0 : \rho = 1$ (unit root, therefore the variable is not stationary); and

$H_1 : \rho = 0$ (no unit root, therefore the variable is stationary).

If the coefficient was significantly different from 1 (less than 1), the hypothesis that y contained a unit root would have to be rejected. Rejection of the null hypothesis denoted stationarity in the series. If we did not reject the null hypothesis, we would have to conclude that we had a unit root. Before conducting the ADF test, we plotted time series plots of the variables to check if there was a trend. The test is very sensitive to lag length; hence, we use Akaike information criterion (AIC) to fix the optimum lag length.

After establishing the unit root or stationarity of our series, we applied the Johansen (1988, 1991) cointegration test and the VECM, which captures both the long-run dynamics and the short-run error correction model (ECM). Testing for cointegration implies testing for the existence of a long-run relationship between economic variables. The Johansen approach is based on estimation by means of likelihood methods, by specifying a VAR equation of the form:

$$\Delta X_t = \coprod X_{t-1} + \sum_{i=1}^{\rho-1} T_i \Delta\, X_{t-1} + \varepsilon_t \tag{2}$$

Where;

$$\coprod = \sum_{i=1}^{p} A_i - I \tag{3}$$

and

$$T_i = - \sum_{i=1+1}^{p} A_j \tag{4}$$

where Δ is the first difference lag operator, X_t is a (*p*× *x*) random vector of time series with *I(1)*, *Γ* is the (*p*× *p*) matrices of parameters, *r* is the number of cointegrating relations or vectors (cointegrating rank), and *i* determines the number of lags specified in the dynamic VAR relationship.

In order to assert cointegration, the Johansen approach estimates the q matrix and tests whether or not we can reject the restrictions implied by the reduced rank of *q*. The focus of the q matrix hinges on Johansen's (1988) suggestion that information on the nature of long-run relationships in the variables is contained in this matrix. In the event that matrix q has a full ranking (i.e. $r = p$), then all the elements in X_t are stationary *I(0)*.

Johansen (1995) derived a maximum likelihood estimator for the parameters and proposed two different likelihood ratio tests for the inference on *r*, namely the trace test (*LRtrace*) and the maximum eigenvalue test (*LRmax*). The trace statistic can test for the null hypothesis of no cointegration (H_0: $r = 0$) against the alternative of cointegration (H_1: $r > 0$) and is specified as

$$\mathrm{LR_{trace}} = -\mathrm{T}\sum_{i=r+1}^{K} \ln\left(1 - \lambda_i\right) \tag{5}$$

where the λ_i is the estimated values of the characteristic roots obtained from the q matrix, *T* is the number of usable observations, and *r* is the number of cointegrating vectors. For any given value of *r*, larger values for the trace statistic are evidence against the null hypothesis that there is *r* or fewer cointegrating equations in the VECM.

The maximum eigenvalue test examines the number of cointegrating vectors, and it conducts tests on each eigenvalue separately. It tests the null hypothesis that the number of cointegrating vectors is equal to *r* against the alternative of *r-1* cointegrating vectors. The maximum eigenvalue statistic is specified as:

$$\mathrm{LR_{max}} = \; -\left(1 - \lambda_{r+1}\right). \tag{6}$$

If the variables in X_t are not cointegrated, then the rank *q* is equal to zero and all the characteristic roots are equal to zero. In the case that *ln* (1) = 0, then each of the expressions in $ln(\lambda_i)$ will be equal to zero in that case.

The reason for the choice to test for cointegration using the Johansen procedure instead of other methods such as the Engle-Granger or the Phillips-Ouliaris methods is that the Johansen procedure is a vector cointegration test method. Hence, it can estimate more than one cointegration relationship if the data set contains two or more time series, as is the case in the present study. The VECM to be applied in the present study is specified as follows:

$$LlnINDI_t = \left\{ \begin{array}{l} \alpha_0 + \sum_{i=1}^{n} \Phi LlnINDI_t \\ + \sum_{i=1}^{n} \delta LlnGDP_{t-1} + \sum_{i=1}^{n} \varphi LlnCPI_{t-1} \\ + \sum_{i=1}^{n} \Omega LlnPrimerates_{t-1} \\ + \sum_{i=1}^{n} \lambda LlnExchangerate_{t-1} + \varepsilon_t \end{array} \right\} \tag{7}$$

$$\Delta lnINDI25_t = \left\{ \begin{array}{l} a_0 + \sum_{i=1}^{n} \Phi \Delta LlnINDI25_{t-1} \\ + \sum_{i=1}^{n} \delta \Delta LlnGDP_{t-1} + \sum_{i=1}^{n} \varphi \Delta LlnCPI_{t-1} + \sum_{i=1}^{n} \Omega \Delta LlnPrimerates_{t-1} \\ + \sum_{i=1}^{n} \lambda \Delta LlnExchangerate_{t-1} + \sigma ECT_{t-1} + \varepsilon_t \end{array} \right\} \quad (8)$$

where σ is the coefficient of the error correction term ECT_{t-1} (which is obtained from the cointegrating vector and measures the feedback effect or the speed of adjustment to long-run equilibrium resulting from a shock to the stock market), t is the error term, and the other variables still maintain their usual definitions. We examined the causal relations of the variables using a Granger causality test.

This study employed the Toda and Yamamoto (1995) Granger causality test under the VAR framework to capture the degree and direction of causality between the variables. The Granger causality test required us to create bivariate VAR models for the data in levels with a lag length $p + m$, where p is the number of lags found in the previous AIC analysis, and m is the maximum order of integration of the variables in the process.

$$Y_t = a_0 + \sum_{i=1}^{p+m} a_i Y_{t-i} + \sum_{i=1}^{p+m} b_i X_{t-i} + \mu_t \quad (9)$$

$$X_t = c_0 + \sum_{i=1}^{p+m} c_i X_{t-i} + \sum_{i=1}^{p+m} d_i Y_{t-i} + v_c \quad (10)$$

We then tested for Granger causality using the Wald test for linear restriction only for the first p lagged values. We tested the null hypothesis that X does not Granger-cause Y:

$$H_0 : \sum_{i}^{p} b_i = 0; H_1 : \sum_{i}^{p} b_i \neq 0 \quad (11)$$

and that Y does not Granger-cause X:

$$H_0 : \sum_{i}^{p} d_i = 0; H_1 : \sum_{i}^{p} d_i \neq 0 \quad (12)$$

We rejected each H_0 if the computed F-statistic was greater than the critical value at a reasonable significance level; otherwise, we did not reject H_0. Rejecting H_0 in Equation 13 implies that the selected macroeconomic variable Granger-caused the INDI 25 values and that past values of macroeconomic variables significantly predicted stock prices. Similarly, rejecting H_0 in Equation 14 also implied that the INDI 25 Granger-caused the selected macroeconomic variable, since such past values of the index can be used to predict the macroeconomic variable in question.

4. Empirical results

The presentation of the empirical results of the study starts with the descriptive statistics, correlation analysis and normality test, where after the results of the various statistical tests are presented to illustrate the presence or absence of relationships between the various variables.

4.1. Descriptive statistics

A descriptive summary of the data is presented in Table 1.

It can be observed that except for the INDI 25 series, all the variables analysed displayed means and median values that were not far apart. This may indicate some form of symmetry in the series, but it does not necessarily imply normality; hence, we needed to test for normality.

4.2. Normality of data

Figure 1 shows the normality plots for the five variables. Except for the exchange rate, none of the variables were normally distributed. The Jarque-Bera (Skewness-Kurtosis) normality tests were applied in order to ascertain this. The results are presented below.

Table 2 presents the Jarque-Bera (S-K) normality test results for all the variables.

The results shown in Table 2 support the findings suggested in Figure 1. Except for the exchange rate, we did not accept the null hypothesis (that the time series are normally

Table 1. Descriptive statistics.

Variable	Mean	Median	Std.Dev.	Min.	Max.	N
INDI 25	19,225	12,640	16,608	4619	66,753	78
CPI	5.937	5.800	2.572	0.400	12.90	78
GDP	3.059	3.150	2.411	6.300	7.600	78
PLR	13.39	12.50	4.173	8.500	25.50	78
EXR	7.579	7.275	1.995	3.960	12.24	78
ERV	0.263	0.179	0.289	0.001	1.819	78

Note 1: INDI 25 is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, EXR is exchange rate, and ERV is exchange rate volatility.

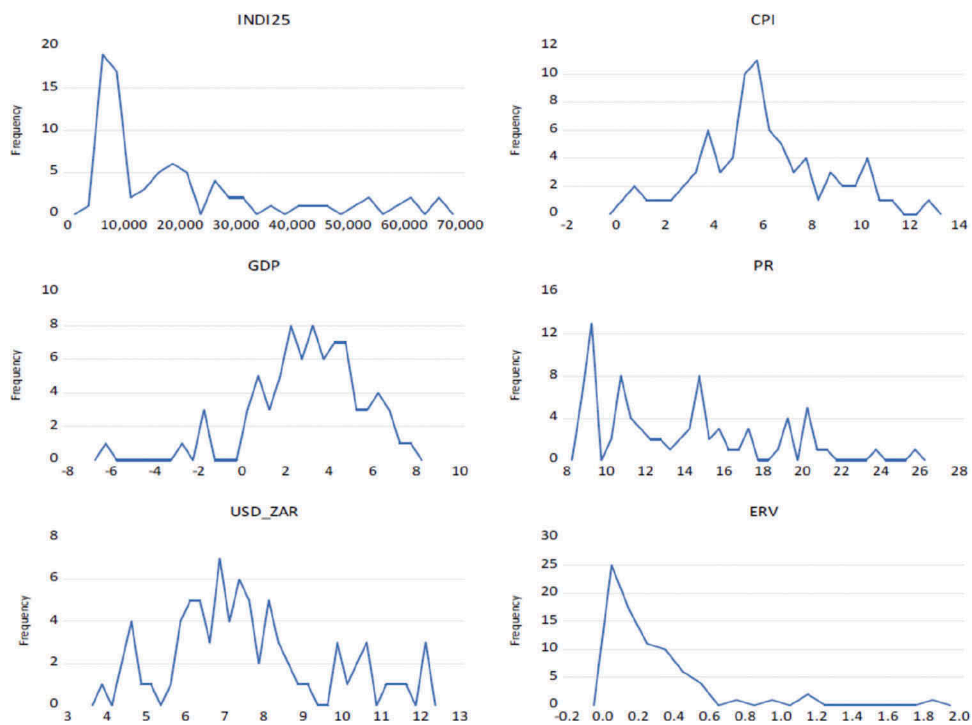

Figure 1. Normality plots.

distributed) at all critical levels. We thus concluded that the INDI 25, inflation, GDP, the prime interest rate and exchange rate volatility series were normally distributed.

4.3. Correlation

We also tested for any linear relationship between the dependent variable and each of the explanatory variables. The scatter plots in Figure 2 below suggest the direction of these relationships.

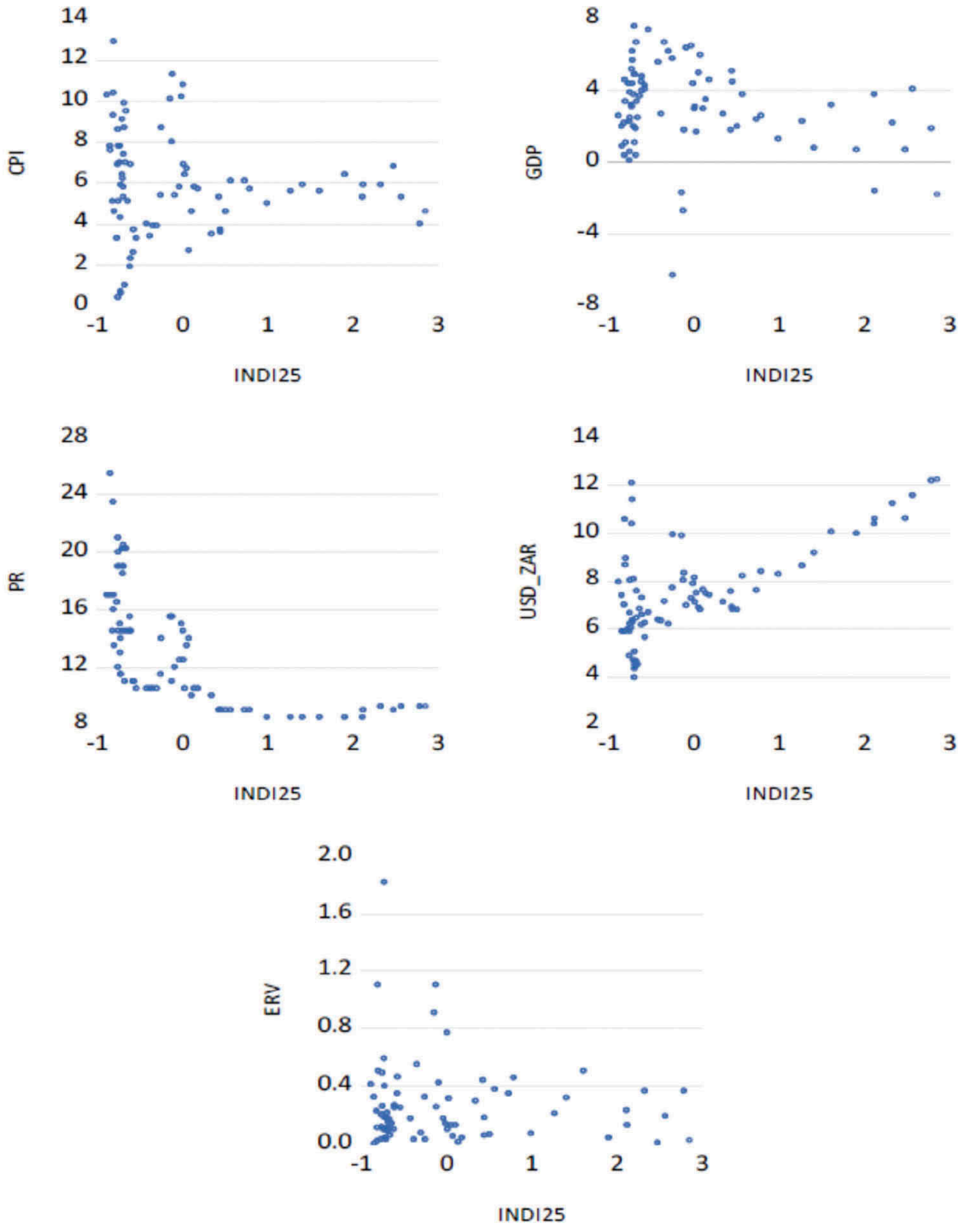

Figure 2. Correlation plots.

Note 1: INDI 25 is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, EXR is exchange rate, and ERV is exchange rate volatility.

Table 2. Normality test results: Jarque-Bera (Skewness-Kurtosis).

	Results					
Variable	N	Skewness	Kurtosis	JB	Prob>χ^2	Description
INDI 25	78	1.488	4.213	33.57	0.0000	Reject H_0
CPI	78	0.220	3.042	6.340	0.0000	Reject H_0
GDP	78	0.871	4.198	21.81	0.0000	Reject H_0
PLR	78	0.749	2.731	7.525	0.0023	Reject H_0
EXR	78	0.561	2.810	4.204	0.1222	Reject H_0
ERV	78	2.802	13.459	45.60	0.0000	Reject H_0

Note 1: INDI 25 is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, EXR is exchange rate, and ERV is exchange rate volatility.

The nature of the relationship between the INDI 25 and inflation and between the INDI 25 and GDP was not linear, compared to that of the INDI 25 and interest rates (which was negative) and that of the INDI 25 and the exchange rate (which was positive). However, the graphical analysis does not necessarily show the strength of this relationship, so we tested for that by conducting correlation tests. The results of these tests are given in Table 3.

As already indicated in the graphical analysis, the INDI 25 displayed a weak insignificant positive relationship with inflation, and a weak insignificant negative relationship with the GDP. However, the relationship between the INDI 25 and interest rates was negative and significant at a 1% level. The INDI 25 and the exchange rate had a significant positive relationship as well as with exchange rate volatility.

4.4. Unit root test results

One of the prerequisites for testing for cointegration is that the series be stationary at the same levels. Therefore, as a next step, we performed the unit root test. For these tests, we used the AIC lag selection criterion for each of the variables. The ADF univariate unit root tests are reported in Tables 4 and 5.

Based on the results presented in Table 4, we could not reject the null hypothesis of a unit root in all the series in their levels at all common significance levels. However, after differencing, as shown in Table 5, we could overwhelmingly reject the null hypothesis of a unit root at all common significance levels for all series. Looking at these results, we concluded that all the variables were I(1), particularly in reference to test statistics at without intercept and trend. However, the plot of the logs of the series suggests that the data might be stationary with a structural break or more than one break (see Figure 3). Accordingly, we deployed the test of unit root against the alternative of trend stationary process with a structural break both in slope and intercept. The results of this test are reported in Table A.1 (see Appendix A). The test results indicate that the break point occurs in all the series and as per the guess from Figure 3.

However, one notable weakness of the ADF test is that it does not have the means of accommodating key information with respect to the existence of structural break arising from the series. For instance, the plot of the logs of the series suggests that the data might be stationary with a structural break or more than one break (see Figure 3). Therefore, we additionally deployed the Zivot and Andrews (1992) (ZA) unit root test to establish whether any possible break point in the series changes the stationarity results. The ZA unit root test has the power of providing key information about the unknown structural break information in the series. The choice of the break date is based on the *t-statistic*, and the break date will be chosen where the confirmations are suitable for the null hypotheses. The results of the ZA unit root test are reported in Table A.1 (see Appendix A). The results indicate that each of the series is non-stationary at level with the presence of structural break point originating within the series. Based on the estimated results, the break point is observed in 2003 (Q1) and 2015 (Q3) for the level data and first difference data, respectively, for the industrial index, in 2003 (Q4) for inflation, in 2009 (Q1) and 2009 (Q3) for the level data and first difference data, respectively, for GDP, in 2008 (Q4) and 1998 (Q3) for the level data and first difference data, respectively, for prime interest rate, in 2011 (Q2) and 2001 (Q4) for the level data and first difference data, respectively, for exchange rate, and in 2001 (Q4) and 1998 (Q2) for the level data and first difference data, respectively, for exchange rate volatility. Still, at first difference, each of the variables is observed to be stationary. This indicates that each of the variables is integrated at I(1) and hence, confirm the deployment of cointegration to examine their long-run relationships.

Table 3. Cross-correlation matrix.

	INDI 25	CPI	GDP	PR	ER	ERV
INDI 25	1.000					
CPI	−0.103	1.000				
GDP	−0.261***	−0.359***	1.000			
PR	−0.652***	0.482***	0.064	1.000		
ER	−0.647***	0.085	0.310	0.523***	1.000	
ERV	−0.839***	0.179	0.080	0.075	0.353***	1.000

Note 1: INDI 25 is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, EXR is exchange rate, and ERV is exchange rate volatility.
Note: *** indicates significant at 10% level.

Table 4. Augmented Dickey–Fuller results: LEVELS.

Variable	Levels	1% C Value	5% C Value	10% C Value	Lag AIC	P-value
INDI 25	−1.177	−4.082	−3.469	−3.162	2	0.999
Inflation	−1.274	−4.082	−3.469	−3.162	2	0.185
GDP	−1.413	−4.082	−3.469	−3.162	2	0.186
Prime interest rate	−3.145	−4.082	−3.469	−3.162	2	0.104
Exchange rate	−1.745	−4.082	−3.469	−3.162	2	0.721
Exchange rte volatility	−7.965	−4.082	−3.469	−3.162	2	0.000

Note 1: INDI 25 is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, EXR is exchange rate, and ERV is exchange rate volatility.
Note 2: First figure relates to test statistics without intercept and trend, while second figures relate to test statistics at intercept only; and * indicates reject null hypothesis at a 1% level of significance.

Table 5. Augmented Dickey–Fuller results: 1st DIFFERENCES.

Variable	Levels	1% C Value	5% C Value	10% C Value	Lag AIC	P-value
INDI 25	−9.074	−4.083	−3.470	−3.162	2	0.0000
Inflation	−6.892	−4.089	−3.473	−3.163	2	0.0000
GDP	−9.749	−4.083	−3.470	−3.162	2	0.0000
Prime interest rate	−6.742	−4.083	−3.470	−3.162	2	0.0002
Exchange rate	−7.650	−4.083	−3.470	−3.162	2	0.0000
Exchange rate volatility	−7.721	−4.083	−3.470	−3.162	2	0.0000

Note 1: INDI 25 is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, EXR is exchange rate, and ERV is exchange rate volatility.
Note 2: First figure relates to test statistics without intercept and trend, while second figures relate to test statistics at intercept only; and * indicates reject null hypothesis at a 1% level of significance.
Note: INDI 25 is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, EXR is exchange rate, and ERV is exchange rate volatility.

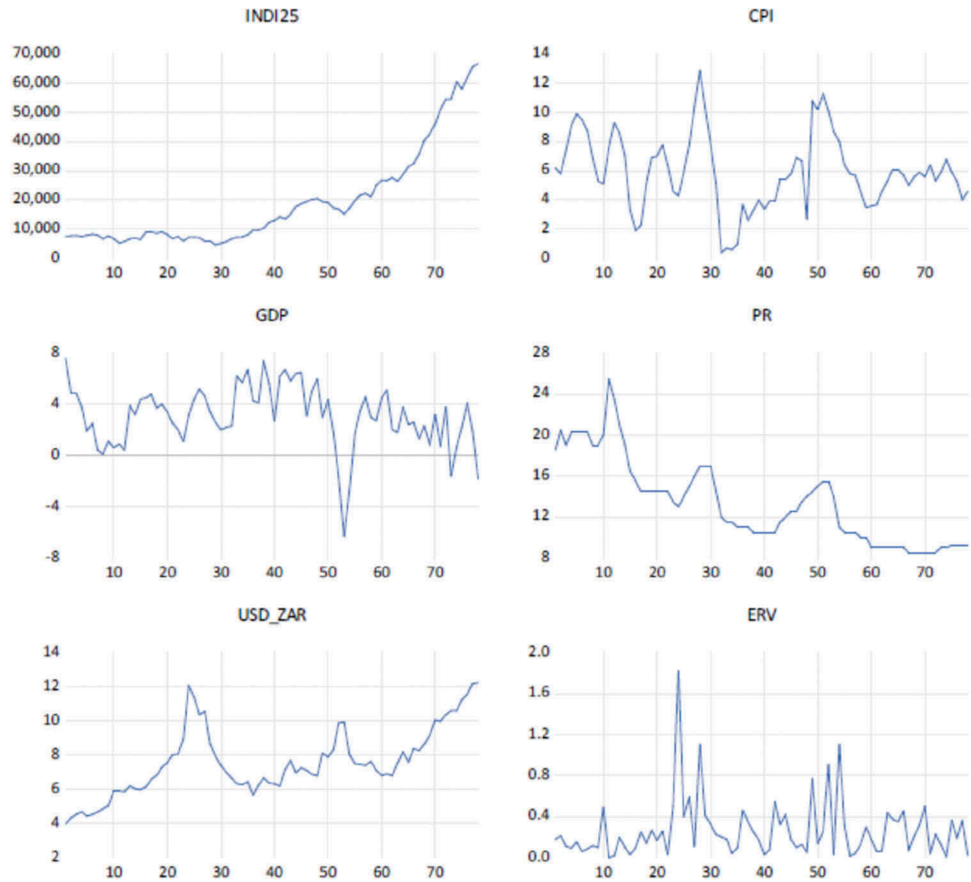

Figure 3. Time Series Plots.

4.5. Cointegration

After establishing the order of integration of variables, we deployed the Johansen test to obtain the presence of cointegration among the variables. The test results are presented below. Based on the results shown in Table 6, we rejected the null hypothesis that the

Table 6. Multivariate Johansen Cointegration Test.

Null Hypothesis	Eigenvalue	J_{trace}	5% C Value	J_{max}	5% C Value
r = 0	0.407	86.79*	69.82	39.18*	33.88
r ≤ 1	0.287	47.61	47.86	25.40	27.58
r ≤ 2	0.189	22.21	29.30	15.69	21.13
r ≤ 3	0.071	6.521	15.49	5.489	14.26
r ≤ 4	0.014	1.032	3.841	3.841	3.841

Note 1: * Reject null hypothesis at a 5% level of significance.
Note 2: AIC is used to choose the optimum lag selection.

variables are not cointegrated. Both test statistics indicated at most two cointegrating relationships, revealing the existence of a long-run relationship between the macroeconomic variables (GDP, CPI, PLR, and EXR/ERV) and the INDI 25 on the JSE.

The normalised cointegration equation of interest is presented in Table 7. This normalised equation can be written as

$$INDI25 = \beta_0 + \beta_1 GDP + \beta_2 CPI - \beta_3 Primerates - \beta_4 Exchangerates \tag{13}$$

By inserting the values of the coefficients into Equation 13, as can be rewritten as follows:

$$\begin{aligned} INDI25 = {} & -41444 + 8127.5GDP + \ 8911.4CPI - \ 1454.9Primerates \\ & - 3683.2Exchangerates \end{aligned} \tag{14}$$

We found a positive and significant relationship between inflation (measured by the CPI) and the INDI 25. During inflationary periods, price increases were often passed on to consumers to enhance company profits. According to Hussain et al. (2012), this profit increase can have a positive impact on company balance sheets and stock prices. Moreover, most companies tend to keep inventory, so price increases result in inventory profits as stock prices increase. This result supports the Fisher hypothesis that there is a one-to-one relationship between stock returns and inflation. In this case, investors received some compensation for inflationary pressures. This finding is consistent with the findings of Firth (1979), Hussain et al. (2012), and Ibrahim and Yusoff (2001). However, this result contradicts the findings of Fama and Schwert (1977), Humpe and Macmillan (2009) and Nelson (1976).

According to the normalised equation above, there was a negative relationship between interest rates and stock prices. This was the anticipated result. When interest rates increase, it presents an increasing opportunity cost of holding money. Therefore, there tends to be a substitution between stocks and interest-bearing securities, which causes a decline in stock prices. This result is consistent with the findings of Chen, Roll, and Ross (1986), Choi and Jen (1991), Gjerde and

Table 7. Normalized Cointegration Equation for JSE.

INDI	GDP	CPI	PLR	EXR	Constant
1.000	8127.5	8911.4*	−1454.9	−3863.2	−41,444.7

Note 1: INDI is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, and EXR is exchange rate.
Note 2: * denotes significance at the 1% level.

Saettem (1999), and Humpe and Macmillan (2009). However, it is contrary to the findings of Maysami, Howe, and Hamzah (2004), and Mukherjee and Naka (1995).

Contrary to expectation, industrial shares (as represented by the INDI 25) and the ZAR/USD exchange rate displayed a positive but insignificant relationship. This result can be explained by the fact that the extent of the impact of exchange rates on stock prices and other economic activities depends on the dominance of the import and export sectors in that specific country. Moreover, this result might be due to some strengthening of the South African Rand against the US Dollar, which would lower import costs and increase the international competitiveness of local producers. This result is consistent with the findings of Maysami, Howe, and Hamzah (2004), and Mukherjee and Naka (1995). However, it is contrary to the findings of Ibrahim and Yusoff (2001), and Kwon and Shin (1999), who found a negative relationship between exchange rates and stock prices.

The present study did not find any relationship between the GDP and industrial shares. This result is consistent with the conventional wisdom that equity market returns are not linked to GDP growth. A number of factors can explain this finding. One can argue that, given the integratedness of the world today, growth in global markets may matter more than growth in local markets. Moreover, although local economic activity matters, in a highly globalised economy, this may be outweighed by economic activity in the rest of the world, which has an impact on stock prices in local markets. We can also argue that it is possible that expected economic growth may be built into the stock prices, thus reducing future realized returns; hence, we failed to observe any impact from economic growth to stock prices (MSCI, 2010).

4.6. Vector error correction model (VECM)

Having confirmed the presence of long-run equilibrium, we could analyse the long-run and short-run dynamics among these variables. Accordingly, VECM was applied at the multivariate level and the results of this estimation reported in Table 8. These results clearly highlight that ECT coefficients are not statistically significant and hence, there is no long-run direction of causality. However, we find short-run direction of causality in a few occasions. These include unidirectional causality from economic growth to inflation, prime lending rate to inflation, exchange rate to inflation, industrial index to prime lending rate, economic growth to prime lending rate, exchange rate to prime lending rate, and economic growth to exchange rate.

4.7. Granger causality

After knowing the VECM estimation among these variables, we also explored the Granger causality between the industrial index (the stock price) and macroeconomic variables (CPI/GDP/PIR/EXR) separately. The estimated results are reported in Table 9.

We analysed causality at a 1%, 5% and 10% level of significance. If the calculated p-value was greater than 10%, we could reject the null hypothesis that Variable X caused Variable Y and would have to conclude that X did not affect or cause the other variable.

Based on the results presented in Table 9, we found no evidence of Granger causality in two of the four models specified, and we could not reject the null hypothesis. However, we found the evidence of univariate Granger causality from the economic growth to industrial index and bidirectional causality between the industrial index and prime lending rate. Some of these results are consistent with the findings of Gan et al. (2006), and Singh et al. (2010).

Additionally, to check the robustness, we have also examined Granger causality between the industrial index with macroeconomic variables, such as CPI, GDP, PIR, and ERV separately. The estimated results are reported in Appendix B (see Tables B.1 – B.3). However, we do not find any difference in findings compared to the previous case where we use the same variables with the exchange rate only.

5. Conclusion

The aim of this study was to address the dearth of research on the relationship between macroeconomic variables and industrial shares, especially on data from an emerging economy. The JSE's INDI 25 is important to the financial markets, as it provides minimal economic cyclicality to investors, compared to highly cyclical stocks, such as resource and financial stocks. Moreover, in recent times, the index has outperformed all other major indices listed on the JSE. This study analysed the

Table 8. VECM Results.

	Independent					
Dependent Variables	INDI	CPI	GDP	PIR	EXR	ECT
INDI	– –	0.966	0.983	0.846	1.422	−0.002
CPI	1.741	– –	7.722*	8.171*	8.828*	−0.003
GDP	2.389	8.086*	– –	4.411**	6.112*	−0.005
PIR	3.384***	1.402	9.88*	– –	4.348**	−0.001
EXR	1.231	1.501	3.356***	0.952	– –	−0.004

Note 1: INDI is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, EXR is exchange rate, and ECT is error correction term.
Note 2: *, **, *** denote significance at the 1%, 5% and 10% levels respectively.

Table 9. Granger causality Wald Tests.

Variables	Alternative Hypothesis	P-value	Decision
GDP	GDP $\Rightarrow$ INDI	0.282	
	INDI $\Leftarrow$ GDP	3.118***	Unidirectional
CPI	CPI $\Rightarrow$ INDI	0.117	Independent
	INDI $\Leftarrow$ CIP	0.294	
PLR	PLR $\Rightarrow$ INDI	3.384***	
	PLR $\Leftarrow$ INDI	3.89***	Bidirectional
EXR	EXR $\Rightarrow$ INDI	0.967	
	EXR $\Leftarrow$ INDI	0.029	Independent

Note 1: INDI is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, and EXR is exchange rate.
Note 2: *** denote significance at the 10% level.

impact of macroeconomic variables on industrial shares listed on the JSE, using the INDI 25 as a proxy for industrial shares. Based on past studies, the macroeconomic variables that were chosen for analysis in the present study were the GDP, the inflation rate, the prime interest rate and the Rand/US dollar exchange rate. Monthly data from 1995 to 2015 were used.

The study applied the unit root test to examine the series for stationarity and structural breaks among the identified variables. The Johansen co-integration method was used to analyse the long-run relationships between the macroeconomic variables and the INDI 25 of the JSE. The VECM was used to reconcile the short-run behaviour of economic variables with their long-run behaviour. We concluded that the macroeconomic variables have a long-run impact on share returns in general, and on the INDI 25 in particular. The results of the study are congruent with those of other South African and international studies that show that share returns are influenced by macroeconomic variables. We found a positive and significant relationship between inflation and stock prices, indicating an inflation premium to investors. As expected, we also found a negative relationship between interest rates and stock prices. This finding suggests substitution between stocks and interest-bearing securities when interest rates increase, which causes a decline in stock prices. The relationship between exchange rates and stock prices was shown to be positive, contrary to our expectations. However, this is not necessarily anomalous in the literature, since the impact of the exchange rate on the stock prices and other economic activity depends on whether an economy is import-intensive or export-intensive.

The importance of industrial shares (which tend to outperform other shares in South Africa) make the results of the present study particularly interesting. Based on the results, it is recommended that portfolio managers and investors alike should be aware that during periods of relatively higher inflation and, independently, a worsening ZAR/USD exchange rate, industrial shares will increase more than in other periods. However, during cycles of higher interest rates, industrial shares will not perform as well as during cycles of lower or decreasing interest rates; thus, portfolios (and investors' expectations) should be adjusted accordingly. In addition, if the interest rate is controlled in the country, it can act as an allocating factor of investors in the industrial index of the stock exchange and investing in other sectors of the economy. Financial regulators should take careful cognisance of these macroeconomic factors when formulating and implementing financial stability policies. South African investors should look at interest rates, exchange rates and inflation as the main sources of systematic risk when formulating hedging and portfolio diversification strategies.

Future studies could include other stock indices as a comparative measure and should also include data from other emerging markets. In addition, macroeconomic variables such as the fiscal balance, oil price, gold price, money supply, foreign exchange reserves and foreign direct investment may be included in future studies. It is likely that increasing volatility of the world's political and macroeconomic variables will in future force investors to take more notice of the influence of macroeconomic variables on stock prices, especially on the stock prices on emerging market economies' stock exchanges. The findings of the present paper contribute towards greater awareness of this.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

John Henry Hall is a full time lecturer and researcher for the past 25 years at the University of Pretoria in South Africa. He has published a large number of papers in international journals, presented papers at international conferences and is a South African national rated researcher.

Kamoto Banda was his full time masters student and is currently in the employ of Barklays Africa in Zambia.

Rudra P. Pradhan is a full time lecturer and researcher at the Vinod Gupta School of Management, Indian Institute of Technology, Kharagpur, India. He has published a large number of papers in international journals and presented papers at international conferences.

ORCID

John Henry Hall http://orcid.org/0000-0003-4471-1034

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Appendix A. Unit Root Test with Break Test

Table A.1. Unit Root Test with break Test

Variable: Industrial Index (INDI) 25	Level Data	First Difference Data
ADF test statistic:	-2.762	-10.37*
Break Point Results:		
INDI (-1)	0.948*	-0.028
C	0.199*	-0.012**
INCPTBREAK	0.045*	-0.007
BREAKDUM	-0.155*	-0.195*
Break Date:	2003 (Q1)	2015 (Q3)
Variable: Inflation		
ADF test statistic Inflation (CPI):	-4.994*	-10.72*
Break Point Results:		
CPI (-1)	0.729*	-0.574*
C	0.216*	-0.002
INCPTBREAK	-0.017	0.019
BREAKDUM	-1.112*	-1.114*
Break Date:	2003 (Q4)	2003 (Q4)
Variable: GDP		
ADF test statistic:	-11.53*	-12.58*
Break Point Results:		
GDP (-1)	0.323*	-0.466*
C	0.688*	-0.015
INCPTBREAK	-0.033***	-0.021
BREAKDUM	-1.044*	-0.668*
Break Date:	2009 (Q1)	2009 (Q3)
Variable: prime interest rate (PIR)		
ADF test statistic:	-2.567	-7.781*
Break Point Results:		
PIR (-1)	0.922*	-0.256*
C	0.090*	0.003
INCPTBREAK	-0.026*	-0.009
BREAKDUM	-0.024	-0.106*
Break Date:	2008 (Q4)	1998 (Q3)
Variable: Exchange rate (USD)		
ADF test statistic:	-3.197	-9.832*
Break Point Results:		
USD (-1)	0.890*	-0.025
C	0.096*	0.017*
INCPTBREAK	0.020**	-0.018**
BREAKDUM	-0.031	-0.131*
Break Date:	2011 (Q2)	2001 (Q4)
Variable: Exchange rate volatility (ERV)		
ADF test statistic:	-11.11	-15.46*
Break Point Results:		
ERV (-1)	-0.039	-0.535*
C	0.163*	-0.021*
INCPTBREAK	0.123**	0.017**
BREAKDUM	1.546*	0.388*
Break Date:	2001 (Q4)	1998 (Q2)

Note: *, **, *** denote significance at the 1%, 5% and 10% levels, respectively.

Appendix B. Nexus between INDI25, CPI, GDP, PR and ERV

Table B1. Multivariate Johansen Cointegration Test (with Exchange rate volatility).

Null Hypothesis	Eigenvalue	*Jtrace*	5% C Value	*Jmax*	5% C Value
r = 0	0.461	109.5a	69.82	46.3a	33.88
r ≤ 1	0.309	63.22a	47.86	27.72a	27.58
r ≤ 2	0.246	35.50a	29.30	21.17a	21.13
r ≤ 3	0.160	14.33	15.49	13.10	14.26
r ≤ 4	0.016	1.228	3.841	1.228	3.841

a Reject null hypothesis at a 5% level of significance

Table B2. VECM results.

	Independent Variables					
Dependent Variables	INDI	CPI	GDP	PIR	ERV	ECT
INDI	—–	1.876	1.098	1.449	3.138	−0.007
GPI	2.254	—–	3.359***	6.022*	8.232*	−0.003
GDP	1.182	4.911**	—–	7.874**	8.579*	−0.005
PIR	3.512***	1.393	8.399*	—–	4.111**	−0.001
ERV	2.906	4.464**	3.353***	0.572	—–	−0.004

Note 1: INDI is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, ERV is exchange rate volatility, and ECT is error correction term.
Note 2: *, **, *** denote significance at the 1%, 5% and 10% levels respectively.

Table B3. Granger causality Wald Tests.

Variables	Alternative Hypothesis	P-value	Decision
GDP	GDP INDI	0.282	Unidirectional
	INDI GDP	3.118***	
CPI	CPI INDI	0.117	Independen
	INDI CPI	0.294	
PLR	PLR INDI	3.384***	
	PLR INDI	3.89***	Bidirectional
ERV	ERV INDI	0.425	
	ERV INDI	6.743	Unidirectionl

Note 1: INDI is industrial index 25, CPI is inflation rate, GDP is economic growth, PLR is prime lending rate, and ER is exchange rate volatility.
Note 2: *, **, *** denote significance at the 1%, 5% and 10% levels respectively.