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THE RELATIONSHIP BETWEEN FINANCIAL INNOVATION AND THE EFFECTIVENESS OF COMMODITY PRICES IN SOUTH AFRICA

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ABSTRACT

Despite being traded for over 100 years and even longer in other regions, commodity prices are still a comparatively indefinite asset class. For this reason, commodity prices are extraordinarily different from bonds and other conventional assets. This study aims to analyse the relationship between stock market returns and commodity prices. This study covers the period from 1980 to 2014. A series of statistical tests such as unit root tests, employed by means of the ADF and the Phillip-Perron test, indicate the presence of stationarity among the series. The Vector Error Correction Model (VECM) is employed to examine whether dynamic linkages exist between the research variables. Evidence suggests that there is a positive long-run relationship between stock market returns and commodity prices in South Africa. Furthermore, gold price, platinum price, and Brent Crude oil price affect JSE movement in the long run.

Keywords: Cointegration, Commodities, Macroeconomy, VAR, Stock Market.
JEL Classification: C2; G13; G14; P43; P45.

INTRODUCTION

According to Shiller (1988) time bonds, stock prices, financial market prices, foreign exchanges and bonds have shown great changes in volatility through time. There are years when prices show vast volatile upswings from day to day. Even monotonous markets have been known to change greatly on a daily and monthly basis. Despite being traded for over 100 years and even longer in other regions, commodity prices are still a comparatively indefinite asset class. For this reason, commodity prices are extraordinarily different from bonds, stocks and other conventional assets. In the midst of these dissimilarities, commodity prices are short maturity claims on real assets, not like financial assets, numerous commodities have manifested seasonality in fluctuations and price levels. All the same, little is known about commodity prices for the reason that there is a scarcity in obtaining data (Gorton and Geert-Rouwenhorst, 2005).

Decades ago an empirical debate concerning the relations between exchange rate and stock prices was initiated by a number of scholars. So, far a great number of empirical studies have been conducted to study this relationship, though some scholars have found opposing results concerning the directionality and existence of the relationship which has thrown finance literature off balance. Earlier studies exposed that there is a significant positive relationship between the variables. Examples of these studies include Aggarwal (1981), Giovannini and Jorion (1987) and Roll (1992). In contrast, other studies such as Soenen and Hennigar (1988) argue that there is a significant negative relationship between the variables. However, Solnik (1987), Bhattacharya and Mukherjee (2003), Franck and Young (1972), Nieh and Lee (2001), Chow et al. (1997) and Bahmani-Oskooee and Sohrabian (1992) concluded that there is no long-run relationship between the variables at all. Thus far, this goes to show that there is no empirical synchronisation among academics concerning the relationship between exchange

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rates and stock prices, which substantiates the need for more research in this area to advance and add to the existing literature.

The main aim of this study is to investigate the relationship between financial innovation (Stock market returns) and commodity prices (Gold, Platinum and Brent Crude Oil). The paper will be divided into six parts. Following the introductory section, Section 2 deals with the theoretical and empirical literature surrounding the relationship between stock prices and commodity prices in South Africa. The methodology employed in the study, empirical model specification and empirical analysis of the adopted tests on South African data will be presented in Section 4. Section 5 presents the results of the relationship between stock prices and commodity prices. Finally, Section 6 gives a general summary of the study's major findings and policy recommendations.

LITERATURE REVIEW

The efficient market hypothesis (EMH) is a stock market theory that suggests that profiting from forecasting price movements is challenging and implausible. The driving force behind price changes is the arrival of new information. In the case of South Africa, a number of scholars have pointed out that the JSE is a weak form efficiency, meaning that historical data is also included in the existing pricing system, but investors cannot use historical data as a tool for profit. In an extensively cited study, Eugene Fama, Lawrence Fisher, Michael Jensen and Richard Roll studied the stock price reaction around stock splits. The authors established that stocks split in good times. On the other hand, following the split, they observed no evidence of normal stock price performance, implying that investors would not be able to profit by purchasing the stock on the split date. The evidence was consistent with the theory of EMH (Clarke, Jandik and Mandelker, 2001).

The Elliot Wave Principle (EWP) is a stock market theory which helps explain how financial markets are traded in repeated cycles. The theory is the cyclical quantification of investor psychology. Elliot's main argument was that crowd behaviour reverses and trends in recognisable and consistent patterns. The EWP occurs in any market with sufficient volume and liquidity. While the real-time application of EWP contrasts between a foreign exchange market and a commodity market, the basic principles governing the theory are equally applicable (Frost and Prechter, 2005).

The relationship between financial markets and oil prices seems to be natural. According to Mussa (2000), commodity prices fluctuations affect economic activity, monetary policy, inflation and corporate profits. Consequently, commodity price increases impacts on financial markets and asset prices. Chen et al. (1986) correspondingly used oil prices as a measure of economic risk in the U.S stock market. Hamao (1998) and Brown and Otsuki (1990) also maintain the findings that oil price plays a pivotal role in pricing equities for the Japanese markets. Ferson and Harvey (1993) used 18 state equity markets data and found that fluctuations in U.S crude oil prices are causal to volatility of the international economy.

Before the early 2000s, evidence suggested that commodity markets were comparatively segmented from each other and outside financial markets. Commodities individually had little positive return relationships with each other (Erb and Harvey, 2006). On daily and monthly basis, commodity returns (especially at short horizons) had an insignificant relationship with the SandP 500 return (Gorton and Rouwenhorst, 2006).

De Roon, Nijman and Veld (2000) and Bessembinder (1992) established that commodity future returns increased with net short points of commodity hedgers after controlling a systematic risk. Stocks whose prices carry a premium for methodical risk only and have a tendency to have substantial return relationships with one another's attributes are in sharp contrast to typical financial assets. Alternatively, these attributes reveal disorganised sharing of commodity price risk, which underlies the long-standing hedging pressure theory of commodity prices that dates back to Keynes (1930), Hicks (1939) and (more recently)

Hirschleifer (1988). This prominent theory suggests that commodity hedgers need to offer a positive risk premium to encourage investors to share the characteristic risk of the long positions.

In forecasting the turning points of an index of commercial shares on the JSE securities exchange, Moolman and Jordaan (2005) examined the feasibility of using leading indicators. The scholars wanted to measure and compare the performance of various leading indicators in leading the commercial share index and in forecasting turning points in the commercial share price index. A multivariate logit model was used and estimated using the leading indicators. It is possible that other leading indicators can lead the prices of certain group of shares (such as commercial shares) even though the overall share price index is a leading indicator in the business cycle. The outcomes of the empirical analysis showed that the best composite model included variables such as the yield spread, composite index of leading indicators, money supply, new orders, building plans, the Rand/US$ exchange rate and the nominal effective exchange rate.

Malik and Hammoudeh (2007) investigated the volatility and shock transmission mechanism between global crude oil markets and the US equity and Gulf equity markets (Bahrain, Saudi Arabia and Kuwait). Except in the case of Saudi Arabia, where volatility spill-over occurs from the equity market to the oil market, the authors documented that volatility spill-over occurs from the oil market to equity markets. Malik and Ewing (2009) employed a bivariate GARCH Model to simultaneously estimate the mean and conditional variance between the five US sectoral indices: industrials, financials, health care and technology, consumer services and oil prices. Significant evidence was found of the transmission of shocks and volatility between financials, oil prices, consumer services, industrials and health care sectors. The most current study by Arouri et al. (2011) investigated the extent of volatility transmission between oil stock markets in Europe and the US at the sector level. They applied a generalised VAR-GARCH approach and discovered volatility spill-over between oil and sector stock returns. The authors also documented that the spill-over is uni-directional (from oil markets to stock markets) in Europe, but bi-directional in the US.

Finally, Mongale and Eita (2014) examined commodity prices and stock market performance in South Africa using the Engle-Granger two-step econometric technique. The author's findings showed that an increase in commodity prices is positively related with an increase in stock market performance and other macroeconomic variables. This study will be adding to this body of literature and further attempting to bridge the gap in the existing studies on a developing economy such as South Africa.

METHODOLOGY

Data and model specification

This study employs time series data. Empirically, time series data assumes that the fundamental time series is stationary (Gujarati, 2003). Studies have nonetheless revealed that the bulk of time series variables are non-stationary (Engle and Granger, 1987). Granger and Newbold (1974) pointed out that the likelihood of obtaining spurious regression was high when utilising a non-stationary time series. Hence in an empirical study, before a scholar analyses the data, a stationarity test should be conducted by means of unit root tests. Various unit root tests are used in econometrics literature, mainly the Augmented Dickey Fuller (ADF) test and the Phillip-Perron (PP) test. This study employs both unit root tests to examine whether the time series data is stationary or non-stationary. The ADF test is achieved using the following regression:

$$\Delta yt = \beta_1 + \beta_2 t + \delta y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta y_{t-1} + \varepsilon_t^{\bullet} \qquad \text{.............................(1)}$$

where Δ is the difference operator, β, δ and α the estimated coefficients, and Y the variable whose time series properties is examined and is the white-noise error term. A non-parametric technique of regulating for higher order autocorrelation in a series is based on the following first order of auto-regressive AR(1) process:

$$\Delta Yt = \alpha + \beta Y_{t-1} + \varepsilon_t \quad \text{...(2)}$$

where α is the constant, Δ the difference operator, Y_{t-1} the first lag of the variable Y, and β is the slope. It is advantageous to test whether a cointegrating relationship between the integrated variables exist when two data series are integrated of the same order. For this reason, the Johansen procedure is carried out (Johansen, 1988; Johansen and Juselius, 1990). The Johansen technique uses a maximum likelihood process to determine the presence of cointegrating vectors in a non-stationary time series as a vector autoregressive (VAR):

$$\Delta Y_t = C + \sum_{i=}^{k} \Gamma_i \Delta Y_{t-1} + \Pi Y_{t-1} + \eta_t \quad \text{...(3)}$$

Method

This study adopts thee vector autoregressive (VAR) method. To an extent the VAR method has become standard over the years in time series modelling. In parallel with the structural approach, it circumvents the need to provide a dynamic theory specifying the relationships among the jointly determined variables. Another advantage is that it can handle endogenous variables on both sides of the equation as well as a mix of 1(1) and 1(0) variables in one system. The VAR system works in such a manner that each variable is regressed in its own lags plus the lags of other variables.

Unit root tests

In econometric analysis, it is applicable to test whether a particular data series is stationary. A non-stationary data series must be differenced "d" times before it can be stationary. Only then can it be said to be integrated of order "d", e.g. I(d). Applying the difference operator more than "d" times to an I(d) process will only result in a stationary data series, but with a moving average error structure. An I(0) is a stationary series, while I(1) has a unit root. An I(2) has two unit roots and so would require differencing twice to prompt stationarity. The Dickey and Fuller (1981; 1984) test and the Phillip and Perron (1988) test are two of many formal tests employed when testing for stationarity. These tests are centred on the following assumptions:

H_o, unit root exists (Accept null hypothesis)

H_1, unit root does not exist (Reject null hypothesis)

Cointegration

A cointegration tests calculates the long-run relationship between economic variables. A time series of two or more cointegrating variables suggests that there is a long-run equilibrium relationship among the variables. Consequently, the econometric analysis of cointegration illustrates that if two or more series related to form an equilibrium relationship in the long run, at that particular time in point may be non-stationary, they move closely together over time and their difference will be stationary. Their long-run relationship is the speed of adjustment to which the system converges over a certain period, and the error term can be interpreted as the disequilibrium error or the disturbance error at time *t*.

Cointegration has two main testing methods, namely the Johansen procedure (Johansen, 1991; Johansen, 1995) and the Engle Granger (EG) two-step method (Engle and Granger, 1987). The Johansen procedure determines the rank of the matrix, while the Engle Granger determines whether the residuals have an equilibrium relationship or whether the series are stationary.

Diagnostic testing

The diagnostic checks are vital to the business cycle model because they authenticate the parameter evaluation outcomes attained by the estimated model. When problems arise in the estimated model's residuals, it means the CLRM is violated and that the model is not the best fit.

Impulse response analysis

When a researcher wants to capture the short-run dynamics of the model, an impulse response functions. These impulse responses trace the effect of a one standard deviation shock in a variable on future and current values of the variables. The econometric model assumes that commodity prices do not react to disturbances in other macroeconomic variables. The shock can be identified through a standard Cholesky decomposition.

The CUSUM test

Lastly the model has to be checked for stability by means of the CUSUM stability test as suggested by Perasan and Perasan (1997). According to Bahmani-Oskooee (2004), the null hypothesis for this test is that the coefficient vector is the same in every period.

RESULTS AND DISCUSSION

Unit root test

The results in Table 1 indicate that the null hypothesis of non-stationarity cannot be rejected when variables are at levels except for the dependent variable (JSE). When the variables are tested in first difference of the series, all the variables become stationary. It can thus be concluded that the variables are first difference stationary: that is, each series is integrated of order one I(1).

Table 1. Unit root test results

Variable	ADF				PP			
	Level		1st Difference		Level		1st Difference	
	Constant	Constant and trend	Constant	Constant and trend	Constant	Constant and trend	Constant	Constant and trend
JSE	-6.251**	-7.984***	-8.755***	-8.691***	-7.397***	-9.873***	-25.15***	-28.67***
BCO	0.242	-0.089	-6.262***	-6.998***	0.459	-1.079	-6.355***	-8.538***
PT	-2.201	-2.418	-4.200***	-4.141***	-1.942	-2.082	-4.158***	-4.095**
COAL	-1.079	-2.182	-5.303***	-5.216***	-1.117	-2.360	-5.295***	-5.206***
GOLD	1.349	-0.706	-3.490***	-3.632***	1.348	-0.706	-3.490	-3.632**

Critical values

1%	-3.568	-4.152	-3.571	-4.156	-3.568	-4.152	-3.571	-4.156
5 %	-2.921	-3.502	-2.922	-3.504	-2.921	-3.502	-2.922**	-3.504
10%	-2.598	-3.180	-2.59	-3.181	-2.598	-3.180	-2.599**	-3.181

1. *Using critical values by Mackinnon, 1996.*
2. ** indicates stationary at 1% level, ** indicates stationary at 5% level, *** indicates stationary at 10% level.*
3. *Selection of bandwidth in the case of PP unit root test according to Newey-West, 1994.*

Cointegration

The maximum eigenvalues and the trace test statistics results for the two models are represented in Table 2. The result of the test statistic indicates that the null hypothesis of no cointegration among the variables can be rejected for South Africa. The results also reveal that at least two cointegrating vectors exist among the above stated variables. In a model that employs a VAR system, the existence of a long-run relationship among the variables must be measured. As the variables are cointegrated, the equations of the VAR also include the lagged values of the variables in levels to capture their long-run relationships.

Table 2. Johansen cointegration test

Hypothesised no of CE(s)	Eigenvalue	Trace statistic	0.05 Critical value	Max-Eigen statistic	0.05 Critical value
None	0.860676	119.2970***	69.81889	63.07045***	33.87687
At most 1	0.639879	56.22658***	47.85613	32.68209***	27.58434
At most 2	0.388124	23.54449	29.79707	15.71922	21.13162
At most 3	0.206814	7.825275	15.49471	7.414335	14.26460
At most 4	0.012760	0.410941	3.841466	0.410941	3.841466

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
**denotes rejection of the null hypothesis at the 0.05 level*

Engle-Granger two-step method

A Granger causality test is conducted to capture the direction and the degree of the long-term correlation between stock market returns and commodity prices. The results are represented in Table 3. From the probability statistics given, it can be deduced that the null hypothesis – "BCO does not Granger Cause JSE" – cannot be rejected as the obtained F-statistic, 2.385, is greater than the critical value of 0.05. However, we can reject the null hypothesis – "COAL does not Granger Cause JSE" – since the critical value is greater than the obtained probability value of 0.040, the notion of rejecting the null hypothesis also applies to the following, "GOLD does not Granger Cause JSE" "COAL does not Granger Cause BCO" and "COAL does not Granger Cause PT." For the rest of the variables stated below, however, it can be concluded that the null hypothesis cannot be rejected, indicating no causal relationship among the variables.

Table 3. Granger causality tests

Null Hypothesis	F-Statistic	Probability
BCO does not Granger Cause JSE	2.38494	0.0942
JSE does not Granger Cause BCO	0.40373	0.7516
PT does not Granger Cause JSE	0.74833	0.5340
JSE does not Granger Cause PT	1.50528	0.2385
COAL does not Granger Cause JSE	3.22685*	0.0403
JSE does not Granger Cause COAL	0.38522	0.7646
GOLD does not Granger Cause JSE	2.74067*	0.0055
JSE does not Granger Cause GOLD	0.15284	0.9268
PT does not Granger Cause BCO	0.25174	0.8593
BCO does not Granger Cause PT	0.20113	0.8946
COAL does not Granger Cause BCO	7.43516*	0.0011
BCO does not Granger Cause COAL	0.34199	0.7952
GOLD does not Granger Cause BCO	1.90035	0.1565
BCO does not Granger Cause GOLD	2.11093	0.1253
COAL does not Granger Cause PT	0.29732*	0.0270
PT does not Granger Cause COAL	1.02315	0.3999
GOLD does not Granger Cause PT	0.22990	0.8746
PT does not Granger Cause GOLD	0.04720	0.9861
GOLD does not Granger Cause COAL	1.74136	0.1853
COAL does not Granger Cause GOLD	16.9002	4.E-06

**indicates significant causal relationship at 5%*

Table 4. Normalised cointegration equation

Normalised cointegrating coefficients (standard error in parentheses)

D(JSE) D(BCO) D(PT) D(COAL) D(GOLD)

1.000000	0.073920	4.546651	-2.825069	47.54217
	(0.04620)	(4.19277)	(36.6070)	(15.3503)

4.4 Vector Error Correction Modelling

Table 5. VECM, short-run analysis

Modelling the VECM		
Independent variables	Coefficient	t-value
Constant	1.527	0.101
$DBCO_{t-1}$	-0.118	-0.054
DPT_{t-1}	-0.005	-0.279
$DCOAL_{t-1}$	-0.003	-1.009
$DGOLD_{t-1}$	-0.006	-0.895
ECT_{t-1}	-0.321	-1.747
$R^2 = 0.659$	RESET Test, 0.046	Normality Test, 0.029
Note: Normality is the Jarque-Berra test for normality of the residuals; RESET is a general test for model mis-specification.		

The estimated ECM for South Africa takes the following form:

$$\Delta JSE_{it} = \alpha + \Sigma\beta_{1i}\Delta BCO_{it-1} + \Sigma\beta_{2i}\Delta PT_{it-1} + \Sigma\beta_{3i}\Delta COAL_{it-1} + \Sigma\beta_{4i}\Delta GOLD_{it-1} + \varphi ECT + u_{1it}$$

Where Δ is the difference operator, JSE_t, BCO_t , PT_t , $COAL_t$ and $GOLD_t$ are as defined before, ECT_{it-1} is an error correction term resulting from the long-run cointegrating relationship, U_{1t} is the white noise error terms, t denotes the years and n_1 is the lag orders of α's and β's respectively. The coefficients indicate that there is a long-run causal relationship the independent and independent variables, while the ECM shows the speed of adjustment to the long-run equilibrium relationship. The following ECM was formulated using 33 observations:

$$DJSE_{it} = 1.527 - 0.109DBCO_{t-4} + 1.335DPT_{t-4} - 30.178DCOAL_{t-4} - 29.991DGOLD_{t-4} - 0.321ECT_{t-1}$$

Se. (15.0205) (0.01722) (2.73199) (21.5463) (5.30602) (0.18357)

The error correction term is negative and significant at 10%. This implies that the model is stable and supporting cointegration results. A value of -0.321 of the error term coefficient indicates that the South African economy -0.321 movement back towards equilibrium following a back towards long-run equilibrium after a fluctuation on the stock market turnover. The R^2 of the model is 65%, which suggests that the model is a good fit.

Diagnostic tests

The diagnostic test results are presented in Table 5, and these assist in checking for serial correlation, normality and heteroscedasticity. These diagnostic checks are based on the null hypothesis that there is no serial correlation for the LM test, there is normality for the Jarque-Bera test and there is no heteroscedasticity for the White heteroscedasticity test.

The estimated model fits well with an adjusted R^2 of 66%. Furthermore, the LM test, which is a stricter test for correlation, is also applied in the analysis. The results for the diagnostic checks for serial correlation, normality and heteroscedasticity show that the data is fairly well behaved.

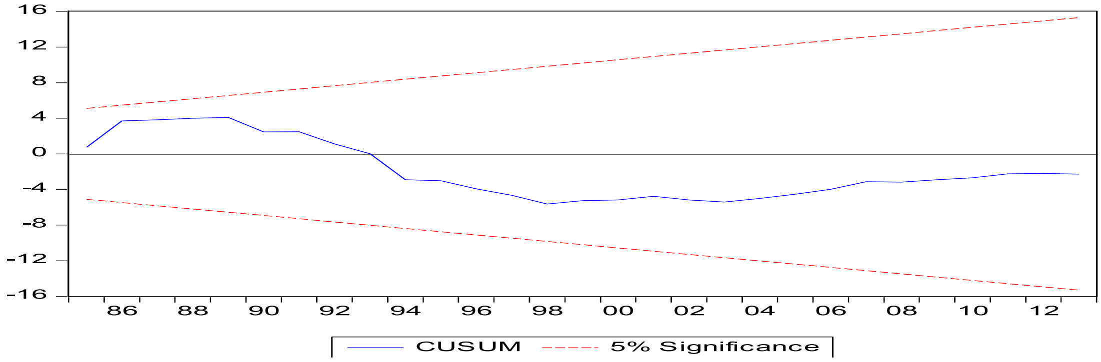
Table 6. Diagnostic test summary

Test for	Test	p-value	Conclusion
Normality	JB	0.029	Accept Ho
Serial correlation	LM	0.005	Accept Ho
Heteroscedasticity	Breusch-Pagan	0.005	Accept Ho

CUSUM test

The plot of the CUSUM of recursive residual stability test in Figure 1 indicates that all the coefficients of the estimated model remain stable over the study period since they are within the 5 percent critical bounds.

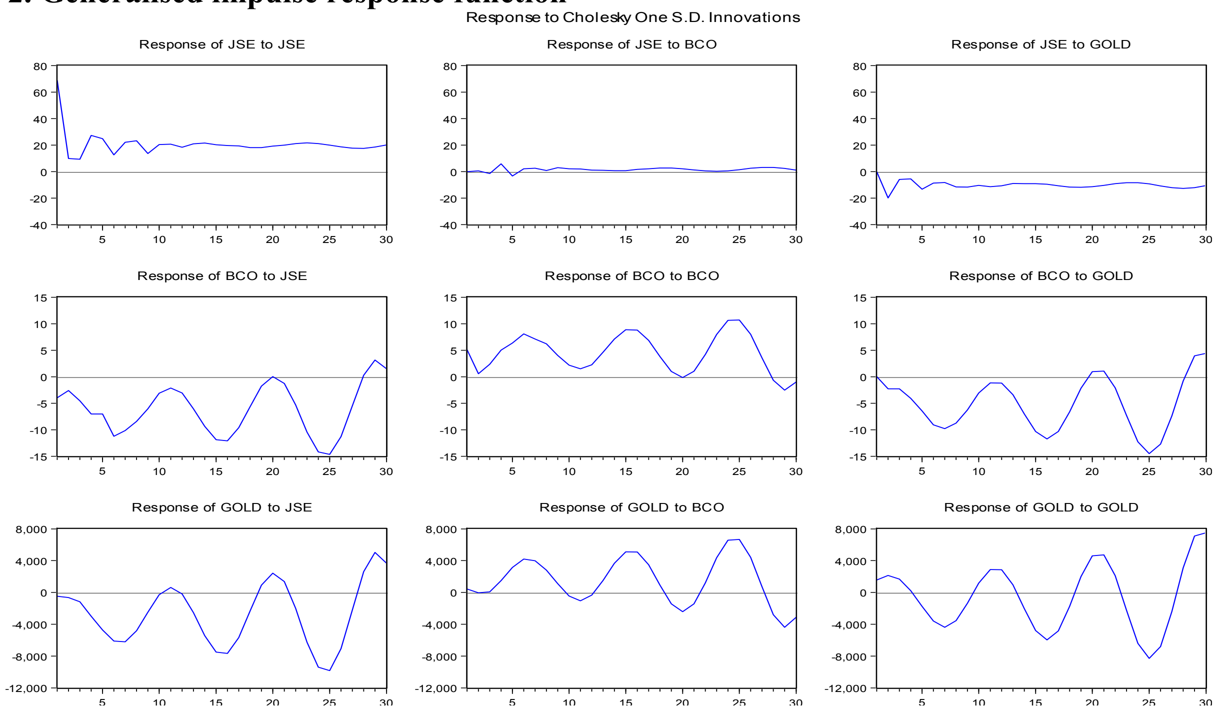
Figure 1. CUSUM test



Impulse Response Analysis Function

Figure 2 shows the accumulated response to stock market returns over a period of 30 years. These results suggest that a rise in the stock market returns has positive effects on the variable itself. A one stand deviation of JSE induces a decrease in BCO and GOLD, while remaining steady in itself. On average, the unexpected standard deviation in BCO prompts a steady decrease in JSE and GOLD and an increase in BCO. A one standard deviation shock of GOLD encourages a decrease in JSE, BCO and GOLD. These results suggest that stock market returns have a positive effect on GOLD over the years, as expected, whereas it leads to a decrease in COAL over the preceding period.

Figure 2. Generalised impulse response function



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CONCLUSION AND RECOMMENDATIONS

This study empirically examines the dynamics between the volatility of stock market returns and the movement of the commodity prices in relation to the degree of interdependency and causality in South Africa. Firstly, the unit root test was employed to test whether the data series was stationary. The results confirmed that all the data series of the variables are non-stationary and integrated of order one. The Johansen procedure was then used to test for the possibility of a cointegrating relationship. The results showed that there is cointegration between stock market returns and commodity prices. This simply suggest that there is a long-run relationship between the variables. The Granger causality test indicates that JSE does not Granger cause Commodity prices. Participants in the commodity markets can use the information from stock prices to forecast on stock market returns of economies in future. Stock markets and commodity prices are, and most likely will continue to be, one of the most dynamic fields in economic analysis.

The results of this study suggest numerous policy recommendations which could fortify the connection between the stock market and commodity prices in South Africa. It is a widely-known fact among scholars that the stock market operates in a macroeconomic background. Stock market management should be deregulated. Market forces of demand and supply should be permitted to function without any influence or interference from external sources.

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