The Impact of Oil Price Changes on FTSE/JSE Industry Indices Performance

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Abstract: The impact of oil price changes on stock market index of the JSE, South Africa, was examined using NARDL model using 2008 -2017 monthly data of aggregated industrial indices. All-Share index was incorporated in the estimation equation to represent market factors.

The results indicate that in the short-term, the indices responded asymmetrically to oil price changes whilst in the long-term they responded symmetrically. Oil & Gas, Industrials, Consumers services and Technology indices followed oil price change direction whereas Consumer goods and Financials indices opposed oil price change direction. Healthcare and Telecommunications responded in one direction irrespective oil price change direction.

Keywords: Non-linear ARDL, Oil prices, Stock Market index, JSE.

1. INTRODUCTION

Extensive research has been conducted to understand the impact of oil price changes on macroeconomic factors (Batac & Tatlonghari, 2013; Hussin, Muhammad, Hussin, & Razak, 2012; Sahu & Mondal, 2015; Sedick, 2016; Wong & El Massah, 2017). Most of these were predominantly based on static techniques lacking the capability for simultaneous long-term and short-term relationship evaluation nor distinguishing between positive and negative changes.

Research efforts to establish the impact of oil prices changes on stock market performance have yielded contradictory findings, e.g. for South African alone, one group of researchers found minimal impact of oil price changes on stock markets (Chinzara, 2011) yet another group reported a positive relationship between world oil price changes and stock prices (Chisadza, Dlamini, Gupta, & Modise, 2016).

Oil price changes have varying economic performance impact on oil exporting countries compared to oil importing countries. For oil exporting mono-structured economies, like Nigeria, economic performance follows oil prices change direction due to impact on export revenue (Adetunji Babatunde, Adenikinju, & Adenikinju, 2013). However, oil importing countries like South Africa performance opposes the oil price change direction. Increase in oil price leads to cost of production increase resulting in companies reducing their production output to reduce cost if prices are maintained the same. In the event of increased prices to offset the increased cost of production, demand for the products will decrease. (Sahu & Mondal, 2015). Figure **1** shows the historic performance of the nine industry indices on the JSE over the 10 year period under evaluation.

This understanding on the impact of oil price changes on macroeconomic variables such as GDP growth (Balcilar, van Eyden, Uwilingiye, & Gupta, 2017; Lardic & Mignon, 2008), exchange rate (Adebiyi, Adenuga, Abeng, & Omanukwue, 2009; Hussin *et al*., 2012; Iheanacho, 2016; Lawal, Somoye, & Babajide, 2016; Sahu & Mondal, 2015; Sedick, 2016) and inflation (Cologni & Manera, 2008; Cunado & De Gracia, 2005; Duma, 2008; Lacheheb & Sirag) prompted the need to understand whether oil price changes have impact on stock market performance. Researchers have since used various methods to evaluate this impact at different levels of the stock market (Maghyereh, 2006; S. Mohanty, Nandha, & Bota, 2010; Ogiri, Amadi, Uddin, & Dubon, 2013; Salisu & Oloko, 2015; Scholtens & Yurtsever, 2012; Shammas, 2012; Zhang & Chen, 2011; Zhu, Li, & Yu, 2011)

There remains the need to understand how various stock market industries are impacted by oil price changes and whether this impact is long-term or short-term and how symmetrical is it. Looking at typical historical relationship between oil price and two of South African industry indices, Figure **2a** and **b**, it appears that Basic Materials (J510) are highly impacted by oil price changes than Consumer goods (J530) industry. These high-level observations cement the need to understand variations of oil price change impact on different industries.

This research seeks to investigate the impact of oil price changes on industry performance in the South African context as measured by stock market performance using a newly developed dynamic method, the NARDL.

The method allows to evaluate the impact of oil price changes in both the short-term and long-term and whether these changes price have symmetrical effect on the performance on industry performance. The

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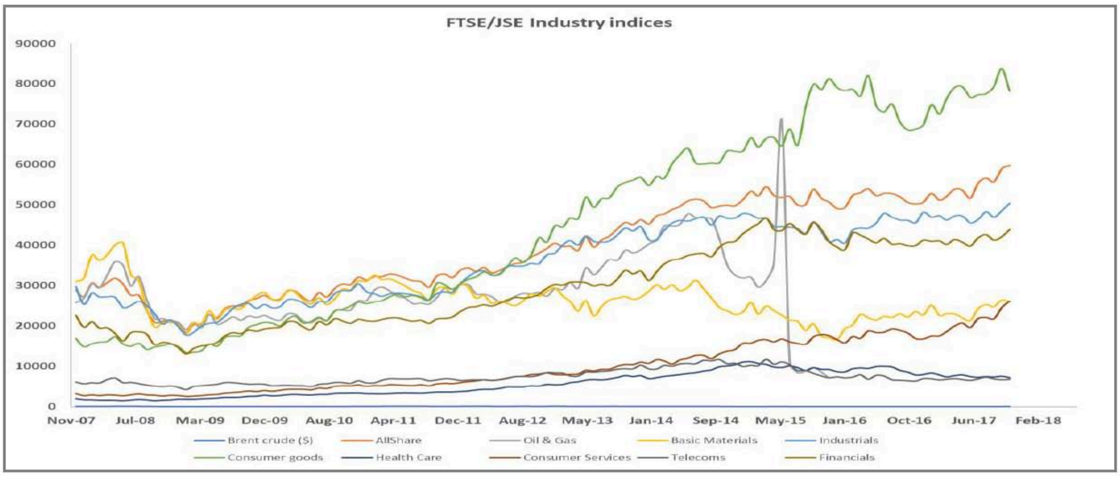

Figure 1: Performance of FTSE/JSE industry indices between Dec 2007 and Nov 2017.

Source: IRESS.

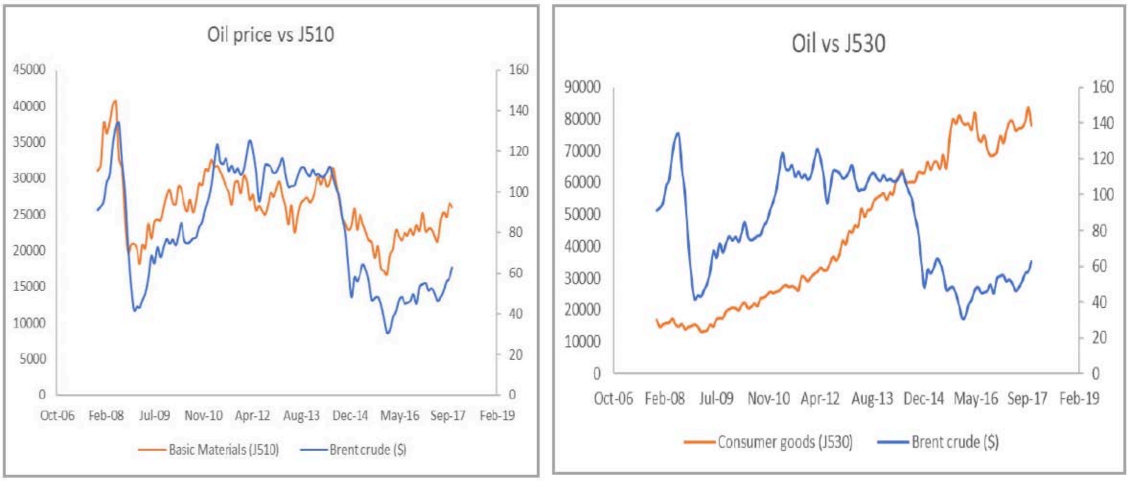

Figure 2: (**a**) FTSE/JSE Basic Materials J510 index and (**b**) FTSE/JSE Consumer Goods J530 index vs oil price between Dec 2007 and Nov 2017.

Source: IRESS.

method provide a multi-dimensional view which is not offered by traditional static methods.

2. LITERATURE REVIEW

Oil is one of the most critical commodities used in today's world economy. It is used as a major input in petroleum products and by-products of its refinement find use in industries such as chemicals, plastics and electricity generation (Duma, 2008; Sukati, 2013). However, oil price depends on a variety of factors including, market demand, quantity produced, available reserves and geopolitical situation. Researchers have developed increasingly interested on how oil price changes affect economic performance.

An article by Hamilton (1983) on how all US recessions have been preceded by oil price shocks since World War II sparked research on the impact between oil price changes and macroeconomic factors among researchers (Beckmann, Czudaj, & Arora, 2017; Brown & Yücel, 2002; Burbidge & Harrison, 1984; Chou & Tseng, 2016; Cologni & Manera, 2008; Cunado & De Gracia, 2005; Cuñado & de Gracia, 2003; Du, Yanan, & Wei, 2010; Hamilton & Herrera, 2004; Hooker, 1996; Iheanacho, 2016; B. R. Lee, Lee, & Ratti, 2001; K. Lee, Ni, & Ratti, 1995; Mork, 1989; Mork, Olsen, & Mysen, 1994; Moya-Martínez, Ferrer-Lapeña, & Escribano-Sotos, 2014; Tang, Wu, & Zhang, 2010). Mork *et al*. (1994) demonstrated that there was a clear negative correlation between oil price and measures of output or employment after reviewing research findings that followed Hamilton's work.

2.1. Theory of Stock Valuation and Impact of Oil Price

Theoretically oil price volatility impact stock market performance through economic factors such as inflation, interest rates, costs of production, income, economic growth (Moya-Martínez *et al*., 2014). The Arbitrage Pricing Theory (APT), according to Ross

(1976), provides the theoretical background through which multifactor framework is factored into stock market price determination and volatility mechanism (Larsson & Haq, 2016; Ross, 2013).

Micro-based asset pricing models show that there are two types of factors which affect the value of a stock, Firstly, macroeconomic factors such as the foreign exchange rate, interest rate, stock market volatility (or market risk), stock market liquidity, economic growth, industrial production, and factors affecting current and future consumption (Breeden, 2005; Cochrane, 1991; Lintner, 1975; Merton, 1973; Sharpe, 1964; Stulz, 1981). Second type is the portfolio characteristic factors, which include the rate of stock return, the variance of stock return, dividends or earnings, book to market ratios, and the company size (Fama, 1965; Malkiel & Fama, 1970; Ross, 2013).

Economic theory suggests that current stock prices reflect the discounted future cash flows of a particular stock (Degiannakis, Filis, & Arora, 2017; R. D. Huang, Masulis, & Stoll, 1996). This can be shown as:

$$P_{i,t} = \sum_{n=t+1}^{N}\left(\frac{E(CF_n)}{(1+E(r))^n}\right)$$

Where:

CF_n is the cash flow at time n

r is the discount rate.

$E(*)$ denotes the expectation operator

This equation illustrates that stock returns are impacted by factors that can influence expected cash flow and discount rate.

One such factor can be oil price which in theory affects stock returns in two ways

1. Increase in oil price results in increased cost of production, especially for oil-importing countries. The increased cost of production reduces company earnings (if prices are maintained). Increasing product price to offset increasing production costs will cause a decrease in product demand resulting in reduced earnings for the company.

2. Increase in oil price may lead to increased inflation leading to increased interest rates which translate to increased discount rate

2.2. Impact of Oil Price Changes on Stock Markets Performance

Research on the impact of oil price on stock markets only emerged following reserachers' findings on the impact of oil price changes on macroeconomic factors. Some studies reported a negative impact of oil price changes on stock market performance (Aloui & Jammazi, 2009; Asteriou & Bashmakova, 2013; Bachmeier, 2008; Chen, 2009; Cifarelli & Paladino, 2010; Ciner, 2001, 2013; Driesprong, Jacobsen, & Maat, 2008; Filis, 2010; Filis & Chatziantoniou, 2014; Gjerde & Saettem, 1999; Henriques & Sadorsky, 2008; R. D. Huang *et al*., 1996; Jones & Kaul, 1996; Laopodis, 2011; Y.-H. Lee & Chiou, 2011; Miller & Ratti, 2009; Nandha & Faff, 2008; O'Neill, Penm, & Terrell, 2008; Papapetrou, 2001; Park & Ratti, 2008; Sadorsky, 1999, 2001) whilst others reported oil price changes positively impacting stock market performance (Arouri & Rault, 2012; El-Sharif, Brown, Burton, Nixon, & Russell, 2005; Lescaroux & Mignon, 2008; Li, Zhu, & Yu, 2012; Zhu *et al*., 2011). The matter is further complicated by some researcher who reported lack of meaningful link between oil price changes and stock market performance (Cong, Wei, Jiao, & Fan, 2008; R. D. Huang *et al*., 1996; S. Mohanty *et al*., 2010; Sari, Hammoudeh, & Soytas, 2010). The differences in findings can be attributed to complexity of factors considered when evaluating the impact of oil prices;

- The nature of the country studied i.e. the results may differ between oil-exporting and oil-importing countries (Creti, Ftiti, & Guesmi, 2014). The literature reviewed so far appear to indicate that there is a positive relationship between oil price and stock markets in purely oil-exporting countries but varying findings when oil-importing countries are considered

- Model used in the study, as linear based models tend to be static and miss the non-linear component of the impact (Beckmann *et al*., 2017). Many studies on oil price modelling have been conducted in a linear framework yet consideration of non-linear effects appear logical given that various shareholders have different investment timeframes. Furthermore, an investor may be interested in understanding which changes increase risk exposure between positive changes and negative changes.

- Impact timeframe, as long-term study is likely to yield results different from those of short-term studies

- Symmetrical analysis whereby negative changes are likely to have different impact than positive changes. In the literature reviewed, the phenomenon of asymmetry effect has been explored by some researchers and found to exist between oil price and stock markets (Basher & Sadorsky, 2006; Perdiguero-García, 2013; Sadorsky, 1999; Salisu & Oloko, 2015).

2.3. Impact of Oil Price on Sector/Industry Level Stocks

Most of early studies conduct on oil price changes-stock market performance relationship focused on aggregated stock markets. Those that looked at sector based stocks concentrated on the oil and gas sector (Aleisa & Dibooglu, 2004; Boyer & Filion, 2007; Dayanandan & Donker, 2011; El-Sharif *et al.*, 2005; Ghouri, 2006; Lanza, Manera, Grasso, & Giovannini, 2005) and the airline and the transportation sectors (S. K. Mohanty & Nandha, 2011; Morrell & Swan, 2006). Logically these are sectors which appear to be closely linked to the oil industry hence the oil price. These prior studies ignored the less- and the non-oil-intensive sectors such as the industrials and the services sectors (Arouri & Rault, 2012) with the exception of Mohanty *et al.*(S. Mohanty *et al.*, 2010)

A European sector based study found that oil price have significant impact on the various European markets but the magnitude and the direction of the impact varies between different sectors (Arouri & Nguyen, 2010). Similar observations were made on US based study on sectoral level (Malik & Ewing, 2009). These results seem to make logical sense since oil is an input to many production process, it can be expected that sectors would be impacted different, either based on their nature (i.e. oil consumption or oil production) based on the extend of linkage to the oil industry and oil consumption requirements.

From the sectoral based studies conducted so far, the Oil & Gas sector followed the direction on oil price changes, whilst the reverse holds true for all the other sectors. This points towards the understanding that oil price increases have a positive impact on oil-related and oil-substitute sectors, a negative effect on oil-using sectors and no significant effect on non-oil related sectors (such as those dominated by services companies) (Broadstock & Filis, 2014).

2.4. Econometric Models

Until recently, the most commonly used models reported in literature have been linear in nature The shortcomings of linear models have been highlighted in their inability to neither detect non-linear relationships between variables nor capture asymmetric behaviour between variables over time. Non-linear relationships have been reported between oil price and stock markets (An, Gao, Fang, Huang, & Ding, 2014; X. Huang, An, Gao, Hao, & Liu, 2015; Ma, Wei, Huang, & Zhao, 2013; Vacha & Barunik, 2012).

On the other hand, NARDL model by Shin *et al.* in 2014 was developed by extending the ARDL model to produce a fully dynamic model. It is a flexible dynamic parametric framework with which to model relationships that exhibit combined long- and short-term asymmetries. It uses positive and negative partial sum decompositions in detecting the asymmetric effects in the long-term and the short-term periods. The key advantages of this model over the traditional cointegration models includes (Shin, Yu, & Greenwood-Nimmo, 2014);

- Better performance compared to the classical cointegration models
- It is applicable to regressors that are stationary at level of first difference (i.e. I(0) or I(1)) and,
- Has the ability to detect hidden cointegration

The impact of oil price changes on stock market performance remains a complex issue given all these factors that needs to be considered in the analysis. It is therefore critical to utilise a model that covers the parameters that impact the results of the study. As such, the NARDL model presents an opportunity for dynamic analysis on the impact of oil prices changes on stock market performances.

3. METHODOLOGY AND DATA

The oil price used in this study was the price of Brent Crude oil (in USD) on the international market. A brief description of the industry indices is provided in Table **1** whilst the detailed description is provided in Appendix A (see supplementary information).

Monthly historical data for Brent crude oil for the period Dec 2007 to Nov 2017 was obtained from SARB database. Monthly historical data for nine of the FTSE/JSE industry indices was obtained from IRESS (2018) through INERT BTA for the period Dec 2007 and Nov 2017. The FTSE/JSE Utilities index J507 was not used in this study due to its small size and low trading data. On the other hand, the FTSE/JSE Oil & Gas index was not included in this study due to lack of sufficient data caused by changes that took place during the period of study.

3.1. Data Analysis Methodology

The NARDL approach used in this study is an extension of the linear ARDL approach which was proposed by Pearson *et al.* in 2001. To better understand NARDL, the generalised linear ARDL is explained first. The linear ARDL model is an equation that evaluates relationship between two or more variables as stated by the researcher. Equation 1 represent the linear ARDL model (M Hashem Pesaran, Yongcheol Shin, & Richard J Smith, 2001) which tries

Table 1: Brief Description of the JSE Industry Indices

FTSE/JSE Code	Index Name	Description
J203	All-Share	The all index comprises the entire stock indices of the JSE
J500	Oil & Gas	CompaJ500Jnies that are in the oil and gas value chain
J510	Basic Materials	Companies in the chemicals and basic resources.
J520	Industrials	Companies in construction & materials and Industrial goods & services
J530	Consumer Goods	Made up of automotive & parts, food & beverages and personal & household goods
J540	Health Care	Consists of health care equipment & services
J550	Consumer Services	Consists of the retail and media
J560	Telecommunications	Companies in fixed line and mobile telecommunications business.
J580	Financials	Made up of Banks, Insurance, Real Estate and Financial Services.
J590	Technology	Consists of businesses in software & computer services and technology hardware & equipment

to capture relationship between variables in the form of Y = f (X)

$$\Delta Y_t = \alpha_0 + \alpha Y_{t-1} + \alpha_2 X_{t-1} + \sum_{i=1}^{k} \beta_i \, \Delta Y_{t-i} + \sum_{j=0}^{l} \theta_j \, \Delta X_{t-j} + \varepsilon_t \qquad 1$$

Where:

X_t is the logarithm of independent variable (e.g. crude oil prices)

Y_t is the logarithm of the dependent variables (e.g. All-Share index)

α_1 and α_2 are long-term coefficients

β_i and θ_j are short-term coefficients

k and l are the optimal lags for the first differences of variables selected by Schwartz Information Criterion (SIC) and Akaike Information Criterion (AIC).

The term ε_t is the white noise error

In the linear ARDL model, the long-term relationship between the variables is established by testing the null hypothesis of no cointegration ($\alpha_1 = \alpha_2 = 0$)

The NARDL model makes use of positive and negative partial sum decompositions in detecting the asymmetric effects in the long-term and short-term periods (Shin *et al*., 2014). NARDL can analyse the presence of asymmetry in non-stationary variables, therefore it is suitable for exploring price series because they are usually non-stationary.

The approach used in this study follows a similar one utilised by Kisswani and Elian (Kisswani & Elian, 2017) by first hypothesising the long-term equation of indices as follows:

$$Y_t = \alpha_0 + \alpha_1 J203_t^+ + \alpha_2 J203_t^- + \alpha_3 BCO_t^+ + \alpha_4 BCO_t^- + \varepsilon_t \qquad 2$$

Where:

Y_t is the index price

BCO is the Brent Crude Oil price

J203 is the All-Share Index used to factor out market influence

$\alpha = (\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4)$ is the cointegration vector or vector of long-term parameters to be estimated

ε_t is the noise factor

The non-linear cointegration regression is represented as:

$$Y_t = \delta^+ BCO_t^+ + \delta^- BCO_t^- + \pi_t \qquad 3$$

Where δ^+ and δ^- are the associated long-term parameters and BCO_t is a K x 1 vector of regressors

BCO_t^+ and BCO_t^- are the partial sums of positive and negative changes in oil prices:

$$BCO_t^+ = \sum_{i=1}^{t} \Delta BCO_i^+ = \sum_{i=1}^{t} \max(\Delta BCO_i, 0) \qquad 4$$

$$BCO_t^- = \sum_{i=1}^{t} \Delta BCO_i^- = \sum_{i=1}^{t} \max(\Delta BCO_i, 0) \qquad 5$$

Using these four equations (2-5), the linear model is modified to account for asymmetries thus producing the non-linear ARDL model:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2^+ BCO_{t-1}^+ + \alpha_2^- BCO_t^- + \sum_{i=1}^{k} \beta_i \Delta Y_{t-1} + \sum_{i=1}^{n} (\rho_j^+ \Delta BCO_{t-1}^+ + \rho_j^- \Delta BCO_{t-1}^-) + e_t \qquad 6$$

Where Δ is the first difference operator, *k* and *n* are the lag orders and e_t is the white noise error.

$\rho_j^+ = \omega\theta_j^+$ and $\rho_j^- = \omega\theta_j^-$

The long-term asymmetric parameters can be measured as $\delta^+ = \frac{\alpha_2^+}{\alpha_1}$ and $\delta^- = \frac{\alpha_2^-}{\alpha_1}$. These parameters represent the long-term effect of oil price increases and decreases on the stock market indices. If the long-term coefficients $\frac{\alpha_2^+}{\alpha_1}$ and $\frac{\alpha_2^-}{\alpha_1}$ are not the equal then there is symmetry in the long-term. The null hypothesis of $\frac{\alpha_2^+}{\alpha_1} = \frac{\alpha_2^-}{\alpha_1}$ is tested and if this hypothesis is rejected then there is an evidence of long-term asymmetry in the model.

Asymmetric Cointegration Test

Whereas in the ARDL model, the long-term relationship between the variables is established by testing the null hypothesis of no cointegration ($\alpha_1 = \alpha_2^+ = \alpha_2^- = 0$), in the non-linear ARDL model, the long-term ($\alpha_1 = \alpha_2^+ = \alpha_2^-$) and the short-term ($\rho_j^+ = \rho_j^-$) asymmetries are tested using the standard Wald test.

Testing Symmetry

The asymmetric cumulative dynamic multiplier effect of a unit change in BCO^+ and BCO^- on Y_t is investigated as:

$$m_\tau^+ = \sum_{i=0}^{\tau} \frac{\sigma Y_{t+1}}{\sigma BCO_t^+}, m_\tau^- = \sum_{i=0}^{\tau} \frac{\sigma Y_{t+1}}{\sigma BCO_t^-}, \ \tau = 0,1,2,. \quad 7$$

as $\tau \rightarrow \infty$, $m_t^+ \rightarrow \alpha_1$ and $m_t^- \rightarrow \alpha_2$

4. EMPIRICAL RESULTS

4.1. Descriptive Statistics

The descriptive statistics of the data samples used in the analysis are provided in Table **2**. All data series used in the study exhibited low sample standard deviations which indicates that the percentage changes of these samples are clustered close to the mean. The data series of all the samples evaluated displayed a positive skewness. In terms of Kurtosis, all data samples exhibited a leptokurtic tendency having shown excess kurtosis values (k>3). This indicates all the data set have longer flatter tails and higher sharp central peaks. The Jarque-Bera test for normality showed that the data series for J530, J540, J550 and J560 are normally distributed as their Jarque-Bera values are lower than the critical value of 5.99 at 5%. The rest of the data series (BCO, J203, J510, J520, J580 and J590) however, showed tendency to depart from normal distribution as evident from Jarque-Bera values which were higher that the critical value of 5.99.

4.2. Unit Root Analysis

The first step, before the evaluation of the relationship between the changes in oil price and stock market indices returns was to test for unit root analysis in each data series. The testing procedure requires that no I(2) variables be included in the estimates equation. The unit root tests were conducted using the ADF test at 5% and the lag length in all the tests were selected according to the Schwarz Information Criterion (SIC). The results of the unit roots tests at levels [I(0)] and first difference [I(1)] for all the data sets are shown in Table **3**.

The Unit root test results showed that the all the data sets are integrated I(0) and I(1) at 1% and 5% level. No data series was integrated at I(2). This means that there will be no statistical biases with the data sets therefore the estimation of short-term and long-term can be conducted using NARDL

The data sets for BCO, J203, J510, J520, J560, J580 and J590 exhibited neither an intercept nor a trend in their models at both I(0) and I(1). This shows that at both I(0) and I(1) the data was stationary around the zero value. J530 and J550 exhibited an intercept but no trend in their models at I(0), however, they exhibited neither an intercept nor a trend at I(1). The

Table 2: Descriptive Statistics of the Data Sample

	BCO	J203	J510	J520	J530	J540	J550	J560	J580	J590
Mean	0,003	-0,006	0,001	0,004	-0,013	-0,011	-0,018	-0,001	-0,006	-0,009
Median	-0,014	-0,001	0,005	-0,003	-0,012	0,015	-0,025	-0,001	-0,009	-0,012
Max	0,313	0,150	0,256	0,165	0,139	0,151	0,179	0,171	0,156	0,242
Min	0,184	-0,116	-0,167	-0,109	-0,145	-0,125	-0,012	-0,170	-0,116	-0,251
Std. Dev	0,093	0,044	0,075	0,045	0,052	0,051	0,054	0,063	0,046	0,067
Skewness	1,007	0,391	0,455	0,686	0,089	0,497	0,378	0,041	0,613	0,391
Kurtosis	4,687	4,341	3,819	4,339	3,647	3,371	3,228	3,399	4,446	5,207
Jarque-Bera	34,240	11,949	7,443	18,237	2,232	5,584	3,090	0,825	17,831	27,174
pbb	0,000	0,003	0,024	0,000	0,316	0,302	0,213	0,662	0,000	0,000

Notes: BCO denotes Brent Crude Oil, J203 is the JSE AllShare index, J510 is the JSE Basic Materials index, J520 is the JSE Industrials index, J530 is the JSE Consumer Goods index, J540 is the JSE Healthcare index, J550 is the JSE Consumer Services index, J560 is the JSE Telecommunications index, J580 is the JSE Financials index and J590 is the JSE Technology index.

Table 3: ADF Unit Root Test Results of Brent Crude Oil and JSE Indices at 5%

Variable	Levels [I(0)]	1st Difference [I(1)]
BCO	-6,937**[(c)]	-15,220**[(c)]
J203	-11,795**[(c)]	-11,391**[(c)]
J510	-11,888**[(c)]	-10,148**[(c)]
J520	-11,972**[(c)]	-14,154**[(c)]
J530	-14,170**[(b)]	-10,202**[(c)]
J540	-10,670**[(a)]	-11,103**[(c)]
J550	-13,886**[(b)]	-11,001**[(c)]
J560	-12,617**[(c)]	-11,219**[(c)]
J580	-11,862**[(c)]	-13,029**[(c)]
J590	-7,073**[(c)]	-12,045**[(c)]

Notes: * and ** denotes rejection of the Null hypothesis at 5% and 1% level respectively, [(a)] represent models with intercept and trend, [(b)] represents models with intercept only and [(c)] represents models without intercept nor trend.

results observed at I(0) indicate that the data was stationary at a constant value that is not equal to zero.

J540 data exhibited an intercept and a trend at I(0) but neither an intercept nor a trend was observed at I(1). The results obtained at I(0) indicate that the data was stationary at a value that is not equal to zero and there is a no tendency to follow a trend.

4.3. Cointegration Test

The cointegration test estimate Equation 2 using appropriate lag order. Critical values of Case I of Pesaran (2001) were used in our analysis at I(1) for BCO, J203, J510, J520, J560, J580 and J590, the reason being that all the data sets exhibited a model with no intercept and no trend at the I(1). For data sets of J530 and J550 Case II critical values of Pesaran (2001) were used because the data sets exhibited a model with restricted intercept but no trend. The cointegration test results are summarised in Table **4**. A strong presence of cointegration was observed between oil price and the majority of JSE indices which showed cointegration even at 1% level irrespective of the model that the dataset exhibited, as result that is contrary to Abdelaziz, Chortareas, and Cipollini (2008) who reported no cointegration between oil price and stock prices.

However, J510 index returns did not show cointegration with oil price changes due to F- statistic which was lower than the critical value of Case II hence

Table 4: Bounds Tests Results for Non-Linear Cointegration at 1%, 5% and 10% Level of Confidence

Variable	F-Statistic	Conclusion
J510	1,097	No cointegration
J520	46,784***	Cointegration
J530	46,226***	Cointegration
J540	39,636***	Cointegration
J550	48,908***	Cointegration
J560	55,863***	Cointegration
J580	50,952***	Cointegration
J590	59,912***	Cointegration

Significance	Case I Critical values for I(1)	Case II Critical values for I(1)	Case III Critical values for I(1)
10% level	3.28	3.51	4.78
5% level	4.11	4.16	5.73
1% level	6.02	5.58	7.84

Notes: The bounds test critical values are based on Case I and Case II of M. Hashem Pesaran, Yongcheol Shin, and Richard J. Smith (2001). * denotes significance at 10% level, ** denotes significance at 5% level and ***denotes significance at 1% level.

the we failed to reject the null hypothesis that the is no cointegration between the variables and could not be analysed further. Similar result was reported for the Kuwait Stock Market were Basic Materials did not show cointegration with Brent Crude Oil (Kisswani & Elian, 2017). It can be concluded that there is long-term effect on stock market prices from oil price changes on all indices, except for Basic Materials index (J510). This finding which show a predominantly homogeneous long-term effect of oil price changes on stock market indices is contrary to that of Kisswani and Elian (2017) who reported a heterogeneous long-term effect of oil price changes on stock market indices. This was attributed the nature of the two countries used in the studies, i.e. an oil-importing country (South Africa) versus an oil-exporting country (Kuwait) which Kisswani and Elian (2017) studied.

4.5. Residual Diagnostics Tests

Before analysing the model to determine the long-term coefficients and the symmetry in the long-term and short-term, it is important to evaluate the adequacy of the dynamic specifications based on a number of diagnostic tests. The following diagnostics tests were conducted; the stability test was conducted using the Ramsey test, the Jarque-Bera statistic was used to test for the error normality test and the ARCH statistic was used to test for heteroskedasticity and the results are provided in Table **5**.

The RAMSEY's RESET test is designed to test for any mis-specification in the model. This is done by testing if the linear regression is mis-specified. The RAMSEY test therefore tests the null hypothesis that the value of Y is zero. The results shown in Table **5** indicate that the p-values of all the models specified are greater than 0.05 hence the null hypothesis could not be rejected. This indicated that there was no sign of mis-specification in the models.

The Jarque-Bera result is used as a test for normality of the data. Models usually assume that the data be used in the model is from a normally distributed sample. The Jarque-Bera is designed to test the null hypothesis that the sample is from a normal distribution. Based on the results shown in Table **5**, the null hypothesis cannot be rejected. Overall the result indicated that the model passed the normality test.

The ARCH tests results as shown in Table **5** show that the p-values were all greater than 0,05 hence the null hypothesis could not be rejected. This indicated that there was no ARCH effect in the model. Overall, based on these tests, the models passed the diagnostics tests conducted.

4.6. Non-Linear ARDL Estimation

The JSE stock market indices that were found to be cointegrated with oil price were analysed to determine the cointegration values, i.e. the short-term and long-term coefficients. Therefore J510 was not evaluated because no cointegration was observed between the index and oil price data. The diagnostics tests also provided sufficient positive results to continue with analysis as they indicate adequate specifications since the models pass the normality test, and was free of any autocorrelation.

4.6.1. Long-Term Coefficients

The long-term L_{BCO}^{+} and L_{BCO}^{-} coefficients were calculated by the following equations $L_{BCO}^{+} = \frac{-BCO\_P(-1)}{S(-1)}$ and $L_{BCO}^{-} = \frac{-BCO\_N(-1)}{S(-1)}$ where S(-1) represents the coefficients of the stock index e.g. J510 (-1). The results of the long-term coefficients of the oil price and the various stock market indices are shown in Table **6**.

The positive and negative long-term coefficients were both positive for the J520, J550 and J590. The result suggest a response to oil price changes where

Table 5: Diagnostics Test Results of the Different Models

	RAMSEY's RESET	χ^2_{JB}	χ^2_{ARCH}
J510	-0.585 (0.598)	0.224 (0.894)	0.411 (0.522)
J520	1.385 (0.181)	1.488 (0.475)	0.0404 (0.841)
J530	-0.294 (0.653)	0.112 (0.945)	1.933 (0.164)
J540	-0.628 (0.479)	0.725 (0.696)	0.477 (0.490)
J550	-1.195 (0.116)	1.853 (0.396)	2.947 (0.086)
J560	0.258 (0.582)	0.715 (0.699)	0.0984 (0.754)
J580	-0.0847 (0.887)	0.0259 (0.987)	1.476 (0.224)
J590	-0.177 (0.737)	1.748 (0.417)	0.308 0.578

RAMSEY's RESET is the result of the stability tests, χ^2_{JB} indicates the results of the Jargue-Bera normality test and χ^2_{ARCH} indicates results of the heteroskedasticity test.

Table 6: The Long-Term Coefficients of Oil Price Changes on the JSE Stock Market Indices Returns

Index	L^{+}_{BCO}	L^{-}_{BCO}
J520	0,058	0,041
J530	-0,050	-0,052
J540	0,001	-0,020
J550	0,048	0,045
J560	-0,017	0,002
J580	-0,001	-0,017
J590	0,068	0,064

the positive change in the oil price resulted in an increase in the index price and negative change in oil price resulted in a decrease in the index price in the long-term. When evaluating J520 and J550 it was found that in the long-term the impact of oil price changes were of low magnitude where a 10% increase in oil price caused a 0.6%, 0.4% and 0.7% increase for J520, J550 and J590, respectively. This behaviour was also observed when considering decrease in oil prices. J520, J550 and J590 responded more positively to decrease in oil prices compared to oil price increases. The positive and negative long-term coefficients for J530 and J580 were both negative and low in magnitude characterised by a stronger response to oil price decrease compared to oil price increases. The result suggest a response behaviour whereby the positive change in the oil price would result in a decrease in the index price and a negative change in oil price will result in a positive change in index price in the long-term. The result for J540 indicated that both positive and negative changes in the oil price resulted in positive change in the index price and was also characterised by low magnitude coefficients as a 10% increase or decrease would result in 0.01% and 0.02% change respectively. However, J560 showed a behaviour that is contrary to J540 in that the results indicate that both a positive and negative change in oil price resulted in a negative change in the index price but the magnitude of the coefficients remained significantly low as a 10% increase or decrease in oil prices would only cause a 0.2% and 0.02% change in stock price change respectively.

At a higher level, it appears all indices studied where characterised by significantly low magnitude of long term coefficients indicating that the JSE Industrial stock indices are relatively neutral to the oil price changes in the long-term. However, a detailed analysis reveal that JSE Industrial stock indices respond to oil price changes in a heterogeneous manner since direction of long-term impact of oil price changes vary with sector, a finding that is supported by other researchers (Arouri & Nguyen, 2010; Broadstock & Filis, 2014; Malik & Ewing, 2009). Prices changes of Industrials (J520), Consumer services (J550) and Technology (J590) were found to follow the direction of the oil price changes whereas those of Consumer goods (J530) and Financials (J580) opposed the direction of the oil price changes. Healthcare (J540) and Telecommunications (J560) appeared to be influenced by secondary changes as both positive and negative changes led to unidirectional changes for these indices, i.e. positive change and negative change for J540 and J560, respectively. The main characteristic between these two indices is their relatively small market capitalisation size (Healthcare – 6 809 and Telecommunications – 5 633 (Sharenet, 2018))

4.6.2. Test for Long-Term and Short-Term Symmetry

The empirical analysis involves the selection of the best fitting NARDL specifications. This was achieved by estimating the symmetric and asymmetric impact of oil price changes to the stock market prices changes using Equation 2 and 6. The null hypothesis of the symmetry in the long-term versus the asymmetry was tested using the Wald statistic where the null hypothesis of $\frac{\alpha_2^+}{\alpha_1} = \frac{\alpha_2^-}{\alpha_1}$ was tested and if this hypothesis can be rejected then there is an evidence of long-term asymmetry in the model. For short-term symmetry the null hypothesis of symmetry was tested against asymmetry. The Wald test procedure for the test consists of statistic with the null $\sum_{n=1}^{n} \rho_i^+ = \sum_{n=1}^{n} \rho_i^-$. The results of the short-term and long-term symmetry obtained from the Wald test are shown in Table **7**. The test did not include J510 because no cointegration was found between oil price data and this Index. Based on the results provided in Table **7**, it was found that in all the indices evaluated, the null hypothesis of short-term symmetry can be rejected even at 1% level indicating the presence of short-term asymmetric impact of oil price changes on the industrial stock prices. For the long-term symmetry, however, the null hypothesis could not be rejected for all the variable pairs evaluated. This result suggests that there is long-term asymmetric impact of oil price changes on stock market indices were statistically insignificant for the JSE industry stock indices during the period studied.

Table 7: Short-Term and Long-Term Symmetry Test Results

	$W_{SR,BCO}$	$W_{LR,BCO}$
J520	46,784** (0.000)	2.136 (0.148)
J530	46.226** (0.000)	0.0307 (0.861)
J540	39.636** (0.000)	1.655 (0.201)
J550	48.908** (0.000)	0.0492 (0.825)
J560	55.863** (0.000)	0.0011 (0.974)
J580	50.952** (0.000)	2.937 (0.09)
J590	59.912** (0.000)	0.0297 (0.867)

Notes: $W_{SR,BCO}$ denotes the Wald test for the short-term symmetry which tests the null hypothesis $\rho_j^+ = \rho_j^-$ and $W_{LR,BCO}$ denotes the Wald test for the short-term symmetry which tests the null hypothesis $\alpha_2^+ = \alpha_2^-$ in Equation 6. The associated p-values are provided in brackets below the value. * and ** indicates rejection of the null hypothesis of the short-term and long-term symmetry at 5% and 1% level respectively.

Table 8: The Nonlinear ARDL Estimation Results of JSE Stock Indices Against Brent Crude Oil Prices

Independent variable	J520	J530	J540	J550	J560	J580	J590
	NARDL with SR asymmetry	***NARDL with SR asymmetry***	***NARDL with SR asymmetry***	***NARDL with SR asymmetry***	***NARDL with SR asymmetry***	***NARDL with SR asymmetry***	***NARDL with SR asymmetry***
C	0.054 (0.003)	0.029 (0.178)	-0.0009 (0.964)	0.027 (0.122)	-0.020 (0.464)	0.045 (0.006)	-0.088 (0.005)
S(-1)	-1.051 (0.000)	-1.143 (0.000)	-0.979 (0.000)	-1.130 (0.000)	-1.560 (0.000)	-1.120 (0.000)	-1.127 (0.000)
BCO_P(-1)	0.061 (0.115)	-0.057 (0.201)	0.0007 (0.988)	0.054 (0.233)	-0.028 (0.701)	-0.002 (0.961)	0.076 (0.272)
BCO_N(-1)	0.043 (0.231)	-0.060 (0.146)	-0.020 (0.663)	0.051 (0.243)	0.003 (0.960)	-0.019 (0.503)	0.073 (0.246)
ΔBCO_P							
ΔBCO_N							
ΔS(-1)					0.315 (0.000)		
ΔS(-3)	0.130 (0.012)						
ΔS(-4)							0.220 (0.004)
ΔS(-5)							0.232 (0.017)
ΔS(-6)					0.072 (0.127)		0.305 (0.002)
ΔS(-7)							0.189 (0.012)
ΔS(-8)						0.146 (0.001)	
ΔS(-9)	0.149 (0.001)					0.220 (0.000)	
ΔBCO_P(-1)					0.316 (0.004)		
ΔBCO_N(-1)	-0.080 (0.052)						
ΔBCO_N(-2)					0.278 (0.0009)		
ΔBCO_P(-3)	-0.121 (0.021)				0.233 (0.018)		
ΔBCO_N(-3)		0.140 (0.003)					
ΔBCO_P(-4)					0.258 (0.009)		
ΔBCO_N(-4)					0.162 (0.033)		
ΔBCO_P(-5)		0.192 (0.004)			0.321 (0.0007)		
ΔBCO_P(-6)							0.292 (0.0008)
ΔBCO_N(-6)		0.096 (0.050)					
ΔBCO_P(-7)	-0.119 (0.013)						
ΔBCO_N(-7)		0.109 (0.023)	-0.135 (0.006)				

(Table 8). continued

Independent variable	J520	J530	J540	J550	J560	J580	J590
	NARDL with SR asymmetry	*NARDL with SR asymmetry*	*NARDL with SR asymmetry*	*NARDL with SR asymmetry*	*NARDL with SR asymmetry*	*NARDL with SR asymmetry*	*NARDL with SR asymmetry*
ΔBCO_P(-8)		0.135 (0.049)			0.314 (0.001)		
ΔBCO_N(-8)					-0.322 (0.000)		
ΔBCO_N(-9)		0.131 (0.009)					
ΔBCO_N(-10)						-0.086 (0.008)	0.226 (0.019)
ΔBCO_N(-11)							-0.173 (0.014)
ΔBCO_P(-12)	-0.119 (0.017)	0.129 (0.042)				-0.117 (0.005)	-0.221 (0.023)
ΔBCO_N(-12)		-0.202 (0.014)	-0.114 (0.028)				0.214 (0.006)

4.6.3. Short-Term Coefficients

To determine the short-term coefficients, the partial sums of the negative and positive changes ΔBCO (BCO_p and BCO_n) were evaluated. Table **8** show the results of the short-term coefficients. The coefficients of partial sums of positive and negative were not statistically significant at 5% confidence.

CONCLUSION

Econometric models have been employed to study the impact of oil price changes on various economic variables. Predominantly, these models have been linear in nature thus leading to a number of limitations such as providing one dimensional analysis. The development of the non-linear models, especially the NARDL, brought the agility required to simultaneously evaluate both the long-term and short-term dynamics of the relationship and the symmetrical nature of the impact. Using the NARDL, this study analysed the impact of oil price changes on JSE stock market indices at an aggregated industrial index level and found that the impact of oil price on the different stock market indices of the JSE were of varying dimension and magnitude especially in the long term. The long-term coefficient results, however, showed relatively low magnitude long-term coefficients indicating that the impact of oil price did not have a significant long-term effect on the indices. However, the indices responded in heterogeneous manner indicating that oil prices changes had varied impact on the indices. The Wald test showed that the null hypothesis for short-term symmetry in can be rejected even at 1% confidence but the null hypothesis for long-term symmetry could not be rejected with only J580 that can be rejected at 10% confidence. It was therefore concluded that there was short-term asymmetry and long-term symmetry in the price changes of JSE industrial indices in response to oil price changes. The residual diagnostics showed that the model passed the normality test and was free of autocorrelation hence it was a robust model. The result indicate that investors need to consider the short-term asymmetric impact of oil prices on stock market prices when making investment decisions and incorporate the non-linear impact of oil price changes on stock markets. For further study, it is recommended to consider lower level data in order to reduce the impact of aggregation used in market capitalisation so as to unpack the impact of oil prices changes on homogeneous sectors. For example, using level index data would enable to understand the Banking sector and the Insurance are impacted by changes in oil prices. Industry level data is highly consolidated may contain diverse sectors whose response to changes in oil price changes may differ and counteract each other. Furthermore, due to capitalisation mechanisms, the dominant sector in an Industrial index may influence the results thus yielding a result that is not a true reflection of the industrial index composition.

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