



University of KwaZulu-Natal  
College of Law and Management Studies  
School of Accounting, Economics & Finance

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**Ntokozo Nzimande**

**and**

**Simiso Msomi**

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# **Oil Price Shocks and Economic Activity: The Asymmetric Cointegration Approach in South Africa**

**Nzimande Ntokozo Patrick**

**Nzimanden3@ukzn.ac.za**

**School of Accounting, Economics and Finance,  
University of KwaZulu-Natal, South Africa**

**Msomi Simiso,**

**Msomis2@ukzn.ac.za**

**School of Accounting, Economics and Finance,  
University of KwaZulu-Natal, South Africa**

**Abstract:** This study examines the link between oil prices and economic activity proxied by gross domestic product in the context of South Africa. The study employs the asymmetric approach proposed by Schorderet (2004) and advanced by Lardic and Mignon (2008). The use of asymmetric cointegration is owing to the belief that increasing and decreasing oil prices do not have symmetric impacts on economic activity. In this study we document evidence for an asymmetric response of economic activity to oil price shocks. Further, our findings suggest that negative oil price shocks are important relative to positive oil price shocks.

**Keywords:** Oil prices, Economic activity, Asymmetric, Cointegration

**JEL Classification:** C22 E32 Q41 Q42

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## **1. Introduction**

Following Hamilton (1983), a number of studies examined the relationship between oil prices and economic activity using different econometric techniques (see Oladosu, 2009; Cunado & de Gracia, 2005, among others). The remarkable thing is that these studies have reached a consensus that oil prices can have an adverse impact on economic activity. Simply put, rising energy prices tend to negatively impact economic activity, whereas declining oil prices tend to positively impact economic activity. A few studies argued contrary to what appears to be a consensus; for example, Hooker (1996) found no relationship between macroeconomic variables and oil prices. However, in the mid-1980s it was established that the relationship between oil prices and economic activity is not linear but is asymmetric, such that declining oil prices have a less significant positive impact on economic activity, whereas increasing oil prices have a more adversely significant impact on economic activity (see Mork 1989; Mory, 1993; Brown & Yucel, 2002; Zhang, 2008; Lardic & Mignon, 2008, among others). This can therefore provide a justification why Hooker (1996) concluded that the relationship between economic activity and oil prices no longer exists. Hence this paper in the South African context follows the method employed by Lardic and Magnon (2008) to account for the asymmetric response of economic activity to energy prices, particularly oil prices.

Most of these studies have focused on developed economies (Gisser & Goodwin, 1986; Lardic & Mignon, 2008), particularly the United States and G-7 countries, and those that paid attention to emerging economies focused on Asian countries (Cunado & de Gracia, 2005, among others). Although there are some studies that paid attention to South Africa, they were mainly concerned with the relationship between oil prices and inflation (Ajmi, Gupta, Babalos and Hefer, 2015; Chisadza, Dlamini, Gupta & Modise, 2013 among others). Therefore, this study differs from those in the existing literature because the focus is shifted from developed countries to developing countries, particularly African countries and, to be more precise, South Africa, which is a net oil importer and is argued to be energy intensive (Kohler, 2006).

Over the past years oil consumption in South Africa have increased with a steady increase in economic activity. However, South Africa is a small oil importing country and therefore, increasing oil prices could have adverse effect on economic activity. We believe that through proper policy reaction undesirable impact of changing oil prices could be reduced. However, to

design a proper policy response a detailed research on the nature of the relationship between oil prices and economic activity is needed in South Africa. Therefore this study addresses two objectives, (I) we assess the nature of the relationship between oil prices and economic activity using asymmetric cointegration to allow for the possibility of asymmetric relationship as has been documented in the literature and lastly, we assess the impact of both increasing and decreasing oil prices on economic activity. Further, this study differs from existing African and South African studies in terms of the methodology that is employed, as we employ asymmetric cointegration, and to the best of our knowledge this method has never been used before in this context. The technique we use was initially developed by Balke and Fomby (1997), Enders and Slikos (2001), Schorderet (2004) and Lardic and Mignon (2008), among others.

Previewing our results, we document the absence of a long-run association between economic activity and oil prices when the traditional (linear) cointegration approach is employed. However, when we employ the asymmetric cointegration approach, we document evidence for an asymmetric long-run association between oil prices and economic activity, with strong evidence for negative oil shocks and weak evidence for positive oil shocks. Further, we found negative shocks to have a 0.6% impact on economic activity and positive oil shocks to have a 0.1% and insignificant impact on economic activity.

The rest of the study is organised as follows: section 2 provides a concise review of the oil price transmission mechanism in economic activity and a brief review of related literature. Section 3 outlines the methodology employed in the study, section 4 provides and interprets the empirical findings of the study, and lastly, section 5 provides the conclusion and policy recommendations.

## **2. Oil Price-Economic Activity Nexus**

Rising energy prices, particularly oil prices, indicate the increased scarcity of energy input, which is the most essential input into production. Hence, with a given level of both capital and labour there will be less productivity following an increase in oil prices or rather reduced availability of oil as an input, and thus a potential drop in output. Because productivity falls, real wages will also decline and if rising oil prices are expected to be prolonged, some workers may voluntarily withdraw from the labour market and consequently the natural rate of unemployment rises. However, if consumers are expecting the oil price increase to be temporary they may try to maintain their consumption by either saving less (consuming their savings) or borrowing. To

encourage savings or match the increased demand for loans the equilibrium real interest rate will rise and hence the demand for real money balances will decline and the rate of inflation rises. Because input prices (costs of production) have increased, firms will transfer the increased cost of production to consumers in terms of higher prices; this is referred to as the *second-round effect*. Overall rising oil prices reduce gross domestic product (GDP) growth, and increase real interest rates and inflation. Mork, Olsen and Mysen (1994) and Brown and Yucel (2002) argued that the impact of rising oil prices can be transmitted to economic activity through the *real balance effect*. Especially in oil importing countries consumers will need more currency (rands in the case of South Africa) to purchase a barrel of oil, hence the demand for balances will rise and the failure of monetary authorities to meet the rising demand induces a rise in the interest rate and thus a deterioration in economic growth (Brown & Yucel, 2002). The interest rate increases signal the increased cost of borrowing and so discourage large investment with an impact on economic growth. Another channel foregrounded in the literature is the terms of trade. Increasing oil prices imply the deteriorating terms of trade for the oil importing countries. Hence income is being transferred from importing countries to exporting countries in the form of high oil prices.

When oil prices are increasing it is always expected that economic growth will be retarded and that when oil prices are declining growth will be stimulated; however, this has not been the case with the recent 2014 decline in oil prices. Mork (1989) failed to find a significant relationship between oil prices and economic activity, but when separating oil prices into negative and positive changes, he found a significant relationship between the two variables. The same conclusions were reached by Mory (1993) who found that positive oil prices shocks had a significant impact on the economy and they Granger cause macroeconomic variables, whereas negative oil shocks did not.

Cunado and de Gracia (2003) studied the relationship between oil prices and the macroeconomy by means of studying the impact of oil price shocks on inflation and economic activity (proxied by the industrial production index). They found that oil prices have a permanent effect on inflation and a transitory asymmetric effect on economic activity. Cunado and de Gracia (2005) examined the relationship between oil price movements and the macroeconomy by studying the effect of oil price shocks on economic activity and consumer price indexes for the period 1975Q1-2002Q2. They found that oil prices significantly affect both economic activity and price indexes, although the impact is only transitory. Further, they found evidence for asymmetries in the oil economic

activity and price indexes relationship for Asian countries. Zhang (2008) surveyed the link between oil shocks and economic growth in Japan using the non-linear approach developed by Hamilton (2003). He found that a nonlinear relationship exists between oil prices and economic growth. Simply put, increasing oil prices retard economic growth more significantly than declining oil prices stimulate growth. Lardic and Mignon (2006, 2008) examined the long-run association between oil prices and economic activity, using the asymmetric cointegration technique. They found that orthodox cointegration is rejected but there is evidence for asymmetric cointegration. He, Wang and Lai (2010) examined the relationship between global economic activity proxied by the Killian economic index and oil prices. They found that a long-run association between Killian and real futures prices of crude oil. Hamilton (2003) allowed for a nonlinear relationship between oil prices and economic growth. He found that oil price increases are more important than decreasing oil prices.

### **3. Asymmetric Cointegration Methodology and Data**

Two or more series moving together in the long-run are said to be cointegrated (Granger, 1981). These series are often referred to as the '*drunk and his blind dog*'. This is due to that, although these series may wander apart in the short-run, after some time i.e. in the long-run they will always come back to each other. This had attracted interests in assessing relationship between two or more series, such as oil prices and economic growth. However, the challenge in these studies is that they assess linear integration between two or more series (Brown and Yucel, 2002). After shocking findings by Hooker (1996) that the relationship between oil prices have broken- interests in assessing cointegration between oil prices and economic activity were renewed however, using different techniques. Other studies then concluded that relationship between oil prices and economic growth did not broke down as such, rather the structure of the relationship has changed (Zhang, 2008). For this and other reason the need for a model that will be able to assess the changing structure of the relationship between two or more series became a necessity. As a result we employ asymmetric cointegration developed by Schorderet (2004) and applied by Lardic and Mignon (2008) to assess the structure of the relationship between oil prices and economic activity in United States, G7 and Europe.

Following work done by Lardic and Mignon (2006, 2008), in this study we test for asymmetric cointegration. From Schorderet (2003) we apply the necessary condition, which is to decompose time series into positive and negative parts. Schorderet (2003) showed that when starting at a given time series  $\{V_t\}_{t=0}^T$  is decomposable into initial values of the process.

$$V_t = V_0 + V_t^+ + V_t^- \quad (1)$$

Where  $V_0$  denotes the values that occurs in the beginning

$$V_t^+ = \sum_{i=0}^{t-1} 1\{\Delta V_{t-1} \geq 0\} \Delta V_{t-1} \quad (2)$$

And

$$V_t^- = \sum_{i=0}^{t-1} 1\{\Delta V_{t-1} < 0\} \Delta V_{t-1} \quad (3)$$

$\{V_t^+\}_{t=1}^T$  And  $\{V_t^-\}_{t=1}^T$  represent positive and negative cumulative shocks, respectively, that describe the level of prices at the initial time, denoted by  $t$ . When the event in the parenthesis occurs it is represented by 1, which is the indicator function, and 0 otherwise. Then let us consider a series  $V_{1t}$  and  $V_{2t}$  and suppose these series are both not linearly cointegrated but within them there is a linear relationship existing denoted by  $h_t$  such that,

$$h_t = \alpha_0 V_{1t}^+ + \alpha_1 V_{1t}^- + \alpha_2 V_{2t}^+ + \alpha_3 V_{2t}^- \quad (4)$$

Equation 4 consists of a stationary distribution because vector  $\alpha' = (\alpha_0, \alpha_1, \alpha_2, \alpha_3)$  with  $\alpha_0$  or  $\alpha_1 \neq 0$ ,  $\alpha_2$  or  $\alpha_3 \neq 0$ ,  $\alpha_0 \neq \alpha_1$ ,  $\alpha_2 \neq \alpha_3$  therefore the time series can be asymmetrically cointegrated. The relationship between the two series is not the same, when variables are increasing or decreasing (see Granger & Yoon, 2003, among others).

Following argument by Schorderet (2003) that if only one component in each series in equation 4 has a cointegrating relationship that might be an indication of a cointegrating relationship that functions in one direction;

$$V_{1t}^+ = \alpha^+ V_{2t}^+ + h_{1t} \quad \text{where } t=1, \dots, T \quad (5)$$

$$V_{1t}^- = \alpha^- V_{2t}^- + h_{1t} \quad \text{where } t=1, \dots, T \quad (6)$$

According to West (1988) we know regressors consist of a linear trend in mean, equation 4 is normally distributed asymptotically and can be estimated using ordinary least squares (OLS) and in addition common statistical inferences are valid; this is a fairly general condition application. OLS auxiliary model are given by

$$V_{1t}^+ + \Delta V_{1t}^- = \alpha^+ V_{2t}^+ + e_{1t} \quad (7)$$

Or

$$V_{1t}^- + \Delta V_{1t}^+ = \alpha^- V_{2t}^- + e_{1t} \quad (8)$$

We use the traditional Engle and Granger approach to test for the hypothesis of no cointegration, against the alternative of no symmetric cointegration between oil prices and GDP in South Africa; we run the test in equations 7 and 8.

We use annually produced data covering the period 1980-2014. Economic activity proxied by real GDP data has been collected from the South Africa Reserve Bank (SARB), crude oil prices in United States (US) dollars were collected from the World Economic Outlook (WEO) IMF database. We collected USD/ZAR (US dollar/South African rand) exchange rate data from SARB and used them to convert oil prices into domestic oil prices, and lastly, we used the South African consumer price index (CPI) to deflate nominal oil prices to real oil prices; data for the CPI were collected from SARB.

#### 4. Empirical Findings

Similar to Lardic and Mignon (2008), in order to examine the statistical properties of the series, we employ two distinct unit root tests: Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP). Table 1, displays ADF unit root test results, both at levels and at first differences, and similarly, Table 2 displays PP unit root test results, both at levels and in first differences.

**Table 1: ADF Unit root test results**

Augmented Dickey-Fuller Unit Root Test		
Variable(s)	series at levels	series in first differences
lnEA	-0.571958 (1)	-4.859513*** (1)
lnEA	-2.073170 (2)	-4.799252*** (2)
lnOP	-0.727654 (1)	-5.513039*** (1)
lnOP	-1.830923 (2)	-5.823085*** (2)

Notes: In both the augmented Dickey-Fuller and Phillips-Perron unit root tests (1) represents a model with only intercept and (2) represents a model that consists of both trend and intercept. \*\*\* indicates the rejection of a null hypothesis at 1% level of significance.

Source: Author(s) own estimates

**Table 2: PP Unit root test results**

Phillips-Perron Unit Root Test		
Variable(s)	series at levels	series in first differences
lnEA	-1.17787 (1)	-4.739940*** (1)
lnEA	-2.301933 (2)	-4.691779*** (2)
lnOP	-0.673586 (1)	-5.535110*** (1)
lnOP	-1.646581 (2)	-9.587903*** (2)

Notes: In both the augmented Dickey-Fuller and Phillips-Perron unit root tests (1) represents a model with only intercept and (2) represents a model that consists of both trend and intercept. \*\*\* indicates the rejection of a null hypothesis at 1% level of significance.

Source: Author(s) own estimates

Table 1 and Table 2 suggest that the null hypothesis of a unit root cannot be rejected at levels for both model 1, that is model with only intercept, and model 2, which consists of both intercept and trend. However, both ADF in Table 1 and PP in Table 2 reject the null hypothesis of a unit root at first differences. Hence, we conclude that series are  $I(1)$ . These findings are similar to those of Cunado and de Gracia (2003) and Cologni and Manera (2009), in the case of European countries and China, respectively.

**Table 3: Standard Cointegration (ADF Test on Residuals)**

Augmented Dickey-Fuller Unit Root Test: Residuals	
Residuals	-2.514339 (1)
Residuals	-2.349129 (2)
Phillips-Perron Unit Root Test: Residuals	
Residuals	-2.679056 (1)
Residuals	-2.152811 (2)

Source: Author(s) own estimation

Having examined stationarity properties of the data and established that oil prices and GDP are cointegrated of order one. We examined the orthodox cointegration between oil prices and GDP. Conventional cointegration suggests that there is no long-run association between oil prices and economic activity. Simply put, relying on the ADF and PP unit root tests we failed to reject the

null hypothesis of a unit root on the residuals. Put differently, our results suggest that when using the traditional (linear) cointegration technique the relationship between oil prices and economic activity is only constrained to a short-run. These results are similar to those found by Lardic and Mignon (2008) and Cunado and de Gracia (2005). The failure to find a cointegrating relationship between economic activity and oil prices suggests that the impact of oil prices is only limited to the short run and therefore oil price shocks do not affect economic activity in the long run. Lardic and Mignon (2008) argued that the failure to find a long-run relationship between oil prices and economic activity could be owing to the fact that standard cointegration is too restrictive. Hence, we apply asymmetric cointegration to further scrutinise the relationship between oil prices and economic activity.

**Table 4: Unit Root test on residuals-positive component of oil prices**

<b>Augmented Dickey-Fuller Unit Root Test: residuals++</b>	
Residuals	-4.860513*** (1)
Residuals	-4.813008*** (2)
<b>Phillips-Perron Unit Root Test: Residuals++</b>	
Residuals	-4.737366*** (1)
Residuals	-4.680542*** (2)

Source: Author(s) own estimation

**Table 5: Unit root tests on Residuals-Negative Component of oil prices**

<b>Augmented Dickey-Fuller Unit Root Test: Residuals--</b>	
Residuals	-5.383302*** (1)
Residuals	-5.321444*** (2)
<b>Phillips-Perron Unit Root Test: Residuals--</b>	
Residuals	-5.333776*** (1)
Residuals	-5.269633*** (2)

Source: Author(s) own estimation

In contrast to what has been documented in the literature, our findings suggest that, indeed, the association between oil prices is asymmetric.

Albeit we find evidence for an asymmetric economic activity response, the response contradicts the findings of previous studies (see Mork, 1989; Mork et al., 1994; Cunado & de Gracia, 2003; Ferderer, 1996, among others).

**Table 6: Oil Prices and Economic Activity Regression:  
Decomposed Data**

<b>Variable</b>	<b>Coefficient</b>	<b>P-value</b>
<b>OP1</b>	0.060** (0.023)	0.0158
<b>OP2</b>	0.016 (0.026)	0.6215

\*\* represents 5% level of significance. In parenthesis are standard errors

NB: OP1 denotes decreasing oil prices and OP2 increasing oil prices

When we ran regressions for both negative and positive values we found that a 10% decline in oil prices significantly improves economic activity by 0.6%, whereas an increase in oil prices does not significantly impact on economic activity: the coefficient is 0.1% for a 10% increase in oil price. The elasticities have been estimated by decomposing real oil prices into positive and negative components (see Mork, 1989). The possible explanation for the insignificant impact of oil prices on economic activity could be that although South Africa is a net importer of oil, the economy is not oil intensive; rather the economy is largely dependent on the abundantly available and cheap coal. In 2004, the South African Department of Energy developed a biofuel strategy to contribute toward the production of renewable energy using agriculture and to reduce the dependence on crude oil. Indeed, our findings show that South Africa is not very vulnerable to positive oil shocks, Nkomo (2006) showed that South Africa's oil vulnerability was 0.034 and energy intensity was falling, therefore signaling the declining vulnerability to oil shocks. Mishkin and Shimdit-Hebbel (2007) argued that countries with inflation targeting are less likely to be severely adversely influenced by oil price shocks. Hence this study indeed argues in favour of this argument. Although our elasticities are different from what other studies have found, they are able to indicate that economic activity is not similar when oil prices increase compared to when they decrease.

The significant positive impact of declining oil prices on economic growth can possibly be explained by the basic law of demand assertions. For a given level of technology and labour, decreasing oil prices improve productivity and hence economic activity. Put differently, decreasing

oil prices reduce the costs of production for oil intensity sectors and hence induces more production and thus employment and therefore increasing economic activity.

## **5. Summary and Conclusions**

In this paper we examined the long-run relationship between oil prices and economic activity proxied by the GDP for the period of 1966-2014, using South African data. Unit root analysis, both the ADF and PP, suggested that series are not stationary at levels, however, they are stationary at first differences. Using a standard cointegration approach we examined the long-run association between the two variables employed in this study. Contrary to existing studies (Lardic and Mignon, 2008, among others), we found that there is no long-run relationship between oil prices and economic activity. Failure to find a long-run association could be owing to the fact pointed out by Lardic and Mignon (2006, 2008) that standard cointegration is too restrictive, and given that Mork (1989) pointed out that the structure of the relationship between oil prices and economic activity has changed. Simply put, the relationship is no longer linear, however, it is asymmetric. We therefore examined the oil price economic activity nexus using an asymmetric cointegration approach developed by Schorderet (2004). Using an asymmetric cointegration approach, our findings support the existing literature that economic activity responds asymmetrically to oil price shocks, such that an increase in energy prices does not affect economic activity, whereas a decrease in oil prices stimulates economic activity.

Overall, although we find evidence for asymmetric cointegration between economic activity and oil prices, South Africa is not vulnerable to oil price shocks. This could be explained by South Africa's reliance on cheap and abundantly available coal. However, Cunado and de Gracia (2003) argued that the choice of modelling oil prices is essential, that is whether one chooses to use national prices or world prices. Thus, for further studies we suggest that cognisance is taken of national prices and also the importance of structural breaks should be taken into account. It is believed that structural breaks could alter the relationship if not taken into account (Hooker, 1996; Cunado & de Gracia, 2003). Having established the documented evidence for asymmetric cointegration, the question is how monetary authorities should react to oil price shocks. We suggest that contrary to the existing view or rather the conventional belief that positive oil shocks are more important than negative oil shocks, monetary authorities should not worry too much about positive oil shocks, depending on the longevity of the shocks. However, monetary authorities should put

more emphasis on declining oil prices because they could lead to so-called demand-driven inflation.

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