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OIL PRICES AND ECONOMIC GROWTH IN SOUTH AFRICA: A TRIVARIATE SIMULATION

In this paper we examine the causal relationship between oil prices, oil consumption and economic growth in South Africa, using a multivariate causality model. We apply the newly developed ARDL bounds testing approach to examine this linkage in a trivariate setting. Contrary to the results of some previous studies, our results show a distinct unidirectional causal flow from oil prices to economic growth in South Africa. In addition, our results show that oil consumption Granger-causes both economic growth and oil prices without any feedback. Given the deterrent effect of oil prices on economic growth and the fact that South Africa has adopted inflation targeting as its policy anchor, we recommend monetary policies should be relaxed during the global oil price shocks in order to protect the country from any possible outcome of a full-blown stagflation scenario.

Keywords: Africa; South Africa; oil prices; oil consumption; economic growth.
JEL Classifications: Q43; C32.

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ЦІНИ НА НАФТУ ТА ЕКОНОМІЧНЕ ЗРОСТАННЯ У ПІВДЕННІЙ АФРИЦІ: МОДЕЛЮВАННЯ ЗА ТРЬОМА ПАРАМЕТРАМИ

У статті вивчено причинний зв'язок між нафтовими цінами, споживанням нафти та економічним зростанням у Південній Африці з використанням мультипараметричної причинної моделі. Застосовано новорозроблений тестовий підхід меж авторегресивного розподіленого лагу для дослідження зв'язку між трьома змінними. Всупереч результатам деяких попередніх досліджень, отримані результати свідчать про виразну односпрямовану причинну залежність економічного зростання у Південній Африці від нафтових цін. Також результати свідчать про грейнджерівську залежність економічного зростання та цін на нафту від споживання нафти, без зворотного зв'язку. Враховуючи стримуючий ефект нафтових цін на економічне зростання і той факт, що Південна Африка взяла регулювання інфляції за політичну мету, рекомендовано послаблення монетарної політики під час глобальних змін нафтових цін, щоб захистити країну від можливих наслідків стагфляції.

Ключові слова: Африка; Південна Африка; нафтові ціни; споживання нафти; економічне зростання.
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ЦЕНЫ НА НЕФТЬ И ЭКОНОМИЧЕСКИЙ РОСТ В ЮЖНОЙ АФРИКЕ: МОДЕЛИРОВАНИЕ ПО ТРЕМ ПАРАМЕТРАМ

В статье изучена причинная связь между ценами на нефть, потреблением нефти и экономическим ростом в Южной Африке с использованием мультипараметрической причинной модели. Был применен новоразработанный тестовый подход пределов авторегрессивного распределенного лага для исследования этой связи по трем переменным. Вопреки результатам некоторых предыдущих исследований, полученные результаты свидетельствуют о выразительной однонаправленной причинной

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зависимости экономического роста в Южной Африке от цен на нефть. Также результаты свидетельствуют о грейнджеровской зависимости экономического роста и цен на нефть от потребления нефти, без обратной связи. Учитывая сдерживающий эффект нефтяных цен на экономический рост и тот факт, что Южная Африка поставила регуляцию инфляции политической целью, рекомендовано послабление монетарной политики во время глобальных изменений цен на нефть, чтобы защитить страну от возможных последствий стагфляции.

Ключевые слова: Африка; Южная Африка; цены на нефть; потребление нефти; экономический рост.

1. Introduction. The relationship between oil prices and economic growth attracted substantial empirical research in recent years. Theoretically, an increase in oil prices has two effects, namely the demand side effects and the supply side effects. On the demand side, an increase in oil prices leads to an increase in transportation costs, which translates into higher prices for consumption goods. This, in turn, lowers the consumption demand, which eventually leads to a contraction in output. On the supply side, a rise in oil prices leads to higher production costs, which force producers to cut back their output — thereby lowering the country's aggregate output. Although a number of studies were conducted on the causal relationship between oil prices and economic growth in developing countries, the majority of these studies concentrated mainly on Asia and Latin America. Very little attention was given to poor sub-Saharan African countries that are, in most cases, hardest hit by the oil price shocks. In fact, it is estimated that higher energy prices can hit the poor twice as hard as those in the highest income group (see UNDP/WB, 2005). Previous studies on this subject also show 3 major limitations. Firstly, the majority of previous studies concentrated mainly on the use of a bivariate causality test and may, therefore, suffer from the omission-of-variable bias (see also Odhiambo, 2008; 2009b). Secondly, some of the previous studies overrelied on the crossectional data to examine the causal relationship between oil prices and economic growth. Yet, it is now clear that the cross-sectional method by lumping together countries that are at different stages of economic development, may not satisfactorily address the country-specific effects. Finally, some of the previous studies mainly used the residual-based cointegration test associated with Engle and Granger (1987) and the maximum likelihood test based on Johansen (1988) and Johansen and Juselius (1990) to examine the long-run relationship between oil prices and economic growth. However, it is now well known that these cointegration techniques may not be appropriate when the sample size is too small (see Narayan and Smyth, 2005). It is against this backdrop that the current study attempts to examine the intertemporal causal relationship between oil prices and economic growth using the newly developed ARDL bounds testing approach. By incorporating oil consumption in the bivariate model between oil prices and economic growth, we develop a simple trivariate causality model between oil prices, oil consumption and economic growth. The rest of the paper is structured as follows: Section 2 discusses the trends of oil consumption, oil prices and economic growth in South Africa, section 3 presents the literature review, while section 4 deals with the empirical model specification, estimation technique and the empirical analysis of the regression results. Section 5 concludes the study.

2. Oil Consumption, Oil prices and Economic Growth in South Africa. Although South Africa is one of world's leading exporters of coal, it is a net importer of crude oil. The country has only small deposits of oil and relies largely on imported oil. In fact, it is estimated that about 66% of South Africa's total crude oil consumption is imported. In 2007, for example, South Africa's oil consumption was about 505 000 bbl/d, of which about 306 000 bbl/d was imported. The majority of South Africa's oil imports originate mainly from the Middle East, Iran and Saudi Arabia. There are, however, also small oil imports from African countries such as Nigeria and Angola, among others. In 2006, for example, South Africa imported about 35% of crude oil from Saudi Arabia, 33% from Iran, 16% from Nigeria and 16% from the rest of the world. Currently, the country is estimated to have about 15 million barrels of oil reserves, which are located offshore southern Africa in the Bredasdorp basin and off the West Coast of the country near the border of Namibia (see EIA, 2008). As a net oil importer, South Africa is not exempted from negative effects associated with oil price increases. In fact, the recent oil crisis made the South Africa inflation targeting policy very difficult to implement. This is because higher oil prices add to inflation from the supply side. However, as expected, the Reserve Bank has no choice but to react to the oil-induced inflation by increasing interest rates. The difficulty here is that when inflation is driven by external shocks such as oil price increase, a restrictive reactionary monetary policy such as interest rate hikes may only fuel the inflation rather than reduce it. In such circumstances countries normally end up with a combination of higher interest rates and higher inflation, which is detrimental to economic growth, job-creation and poverty reduction.

Despite the fact that South Africa is a net importer of crude oil, it remains the largest economy in Africa. The country's current GDP is about USD 704 billion, which is approximately 36% of the total sub-Saharan Africa's GDP and 69% of the total SADC's GDP. The country is also ranked number 20 globally in terms of the volume of gross domestic product (GDP). Table 1 shows the trends of oil consumption, real GDP and oil price during the period 1990-2007 compared to 1980.

Table1. **The Trends of Oil Consumption, Real GDP and Oil Prices during the period 1990-2007 compared to 1980**

Year	Real GDP per capita (Rand) — 2005 Prices	Oil Consumption (Thousands barrels daily)	Oil Price (USD per barrel)
1980	32883	253	35.69
1990	30648	355	20.45
1991	29708	358	16.63
1992	28473	369	17.17
1993	28227	383	14.93
1994	28536	400	14.74
1995	28815	426	16.10
1996	29431	437	18.52
1997	29582	444	18.23
1998	29116	450	12.21
1999	29187	461	17.25
2000	29792	475	26.20
2001	30024	486	22.81
2002	30581	499	23.74
2003	30992	512	26.78
2004	31946	523	33.64

Year	Real GDP per capita (Rand) – 2005 Prices	Oil Consumption (Thousands barrels daily)	Oil Price (USD per barrel)
2005	33176	526	49.35
2006	34586	537	61.50
2007	36045	549	68.19

Source: SARB Quarterly Bulletin (various issues); World Development Indicators (2007); IFS Yearbook (2008); BP Statistical Review of World Energy (2008)

3. Literature review. A number of studies examined the relationship between oil prices, energy consumption and economic growth, in both developed and developing countries. In particular, the relationship between energy consumption and economic growth was examined extensively, but the results were remarkably mixed. While studies such as Odhiambo (2009a) for the case of Tanzania, Narayan and Smyth (2008) for the case of G7 countries; Narayan and Prasad (2008) for Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal and the UK; Narayan and Singh (2007) for the case of Fiji; Altinay and Karagol (2005) for the case of Turkey; Wolde-Rufael (2004) for the case of Shangai; Shiu and Lam (2004) for the case of China; Chang et al. (2001) for the case of Taiwan; Yang (2000) for the case of Taiwan; Cheng (1997) for the case of Brazil, and Masih and Masih (1996) for the case of India, among others, maintain that energy consumption Granger-causes economic growth, studies such as Mozumder and Marathe (2007) for the case of Bangladesh; Hatemi-J and Irandoust (2005) for Sweden; Narayan and Smyth (2005) for the case of Australia; Gosh (2002) for the case of India; Cheng (1999) for the case of India; Cheng and Lai (1997) for the case of Taiwan; Abosedra and Baghestani (1989) for the case of the USA, and Kraft and Kraft (1978) for the case of the USA, among others, argue that it is the growth of the real sector that drives the demand for energy from different sections of the economy. Between these two extremes, however, there are studies that argue that both energy consumption and economic growth Granger-cause each other. This view received support from the studies such as Odhiambo (2009b) for the case of South Africa; Paul and Bhattacharya (2004) for the case of India; Yang (2002) for the case of Taiwan; Glasure (2002) for the case of Korea, and Masih and Masih (1997) for the case of Korea and Taiwan. Notwithstanding the predominant view in favour of a causal relationship between energy consumption and economic growth, a few studies such as Cheng (1997) for the case of Mexico and Venezuela; Cheng (1995) for the case of the USA; Yu and Hwang (1984) for the case of the USA, and Akarca and Long (1980) for the case of the USA, assert that energy consumption and economic growth are neutral with respect to each other. In other words, these studies maintain that there is no causality between energy consumption and economic growth.

Unlike the causal relationship between energy consumption and economic growth, the causal relationship between oil prices and economic growth has not been fully explored. Very few studies have fully examined the nexus between oil prices and economic growth. Some of the studies that examined the relationship between oil prices and economic growth include Hanabusa (2009), Jayaraman and Chooing (2009), Prasad et al. (2007), Rautava (2004), Glasure and Lee (2002), Kim and Willet (2000)

and Darrat and Gilley (1996), among others. Darrat and Gilley (1996), for example, find that oil price shocks are not a major cause of the US business cycles. In addition, the study finds that both oil prices and real output cause significant changes in oil consumption without feedback. While examining the relationship between oil price and economic growth in OECD countries, Kim and Willet (2000) find a strong negative relationship between oil price and economic growth. Likewise, Glasure and Lee (2002) find a significant negative relationship between oil price and economic growth for Korea. Using a vector autoregressive (VAR) model, Rautava (2004) finds that Russia's real GDP is negatively affected by oil price fluctuations. In an attempt to investigate the causal relationship between oil price and economic growth in Japan, Hanabusa (2009) finds there is a feedback relationship between oil price and economic growth in Japan. While examining the causal relationship between growth and oil price in small Pacific Island countries, Jayaraman and Choong (2009) find a unidirectional causal flow from oil price and international reserves to economic growth. Although the bulk of the empirical studies support a negative relationship between oil price and economic growth, some recent studies have shown this relationship may not be strictly negative for all the countries. Prasad et al. (2007), for example, while examining the relationship between oil prices and real GDP nexus in the Fiji Islands, find that an increase in the oil price has a positive, albeit inelastic, impact on real GDP. The authors conclude that although their finding is inconsistent with the bulk of the previous literature, it is not a surprising result for the Fiji Islands. Specifically, the authors argue that since the actual output in Fiji has been around 50% lower than its potential output, it has not reached a threshold level at which oil prices can negatively impact output. Moreover, this finding, according to the authors, is consistent with the results from some emerging countries studied by the IMF (2000).

4. Estimation techniques and empirical analysis

4.1. Cointegration. ARDL bounds testing procedure. In this study the recently developed autoregressive distributed lag (ARDL) bounds testing approach is used to examine the long-run relationship between oil prices, oil consumption and economic growth. The ARDL modelling approach was originally introduced by Perasan and Shin (1999) and later extended by Perasan et al. (2001).

$$
\Delta lnOILP_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta lnOILP_{t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta lnOILCON_{t-i} + \sum_{i=0}^{n} \alpha_{3i} \Delta lny_{t-i} +
$$
$$
+ \alpha_4 lnOILP_{t-1} + \alpha_5 lnOILCON_{t-1} + \alpha_6 lny_{t-1} + \mu_t \tag{1}
$$

$$
\Delta lnOILCON_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta lnOILCON_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta lnOILP_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta lny_{t-i} +
$$
$$
\beta_4 lnOILCON_{t-1} + \beta_5 lnOILP_{t-1} + \beta_6 lny_{t-1} + \mu_t \tag{2}
$$

$$
\Delta lny_t = \delta_0 + \sum_{i=1}^{n} \delta_{1i} \Delta lny_{t-i} + \sum_{i=0}^{n} \delta_{2i} \Delta lnOILP_{t-i} + \sum_{i=0}^{n} \delta_{3i} \Delta lnOILCON_{t-i} + \delta_4 lny_{t-1} +
$$
$$
\delta_5 lnOILP_{t-1} + \delta_6 lnOILCON_{t-1} + \mu_t \tag{3}
$$

where: *lnOILP = log* of oil price (USD per barrel); *lnOILCON = log* of oil consumption; *ln y/N = log* of real per capita income; μ_t = white noise error term; Δ = first difference operator.

The bounds testing procedure is based on the joint F-statistics (or Wald statistics) for cointegration analysis (see also Odhiambo, 2009a). The asymptotic distribution of the F-statistic is non-standard under the null hypothesis of no cointegration between the examined variables. Pesaran and Pesaran (1997) and Pesaran et al. (2001) report two sets of critical values for a given significance level. One set of critical values assumes that all the variables included in the ARDL model are I(0), while the other is calculated on the assumption that the variables are I(1). If the computed test statistic exceeds the upper critical bounds value, then the Ho hypothesis is rejected. If the F-statistics falls into the bounds then the cointegration test becomes inconclusive. If the F-statistics is lower than the lower bounds value, then the null hypothesis of no cointegration cannot be rejected.

4.2. Granger Non-Causality Test. Once the long-run relationships have been identified in section 4.1, the next step is to examine the short-run and long-run Granger-causality between oil prices, oil consumption and economic growth using the following trivariate model (see also Odhiambo, 2009b; Narayan and Smyth, 2008).

$$\Delta lny_t = \delta_0 + \sum_{i=1}^{n} \delta_{1i} \Delta lny_{t-i} + \sum_{i=0}^{n} \delta_{2i} \Delta lnOILP_{t-i} + \sum_{i=0}^{n} \delta_{3i} \Delta lnOILCON_{t-i} + ECM_{t-1} + \mu_t \quad (4)$$

$$\Delta lnOILP_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta lnOILP_{t-i} + \sum_{i=0}^{n} \alpha_{2i} \Delta lnOILCON_{t-i} +$$
$$+ \sum_{i=0}^{n} \alpha_{3i} \Delta lny_{t-i} + ECM_{t-1} + \mu_t \quad (5)$$

$$\Delta lnOILCON_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta lnOILCON_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta lnOILP_{t-i} +$$
$$+ \sum_{i=0}^{n} \beta_{3i} \Delta lny_{t-i} + ECM_{t-1} + \mu_t, \quad (6)$$

where *ECMt-1* = the lagged error-correction term obtained from the long-run equilibrium relationship.

Although the existence of a long-run relationship between OILP, OILCON and y/N suggests there must be Granger causality in at least one direction, it does not indicate the direction of temporal causality between the variables. The direction of the causality in this case can only be determined by the F-statistics and the lagged error-correction term (see Odhiambo, 2009a; Narayan and Smyth, 2006). It should, however, be noted that even though the error-correction term has been incorporated in all the equations (4)-(6), only equations where the null hypothesis of no cointegration is rejected will be estimated with an error-correction term (see also Narayan and Smyth, 2006; Morley, 2006; Odhiambo, 2009a).

4.3. Data Source and Definition of Variables

Data Sources. Annual time series data, which covers the 1969-2007 period, has been used in this study. The data has been obtained from the International Financial Statistics (IFS) Yearbook (2008), BP Statistical Review of World Energy (2008) and World Development Indicators (2007).

Definitions of Variables:

i) Real GDP per capita

The real per capita GDP is computed as follows:

Real GDP per capita (y/N) = Real GDP (y)/Total Population (N)

ii) Oil Price

The price of oil is proxied by Dubai price and converted into the local currency, i.e. Price (R/barrel) = Dubai price (US$ per barrel) * Exchange rate

iii) Oil Consumption

Oil consumption data is measured in barrels.

4.4. Empirical Analysis

4.5. Stationarity Tests

The results of the stationarity tests in levels (not presented here) show that all the variables are non-stationary in levels. The next step is to difference the variables once in order to perform stationary tests on differenced variables. The results of the stationarity tests on differenced variables are presented in Table 2.

**Table 2. Stationarity Tests of Variables on first Difference –
Phillips-Perron (PP) Test**

Variable	No Trend	Trend
DLOILP	-5.26319***	-5.23077***
DLOILCON	-8.32148***	-8.08453***
DLy/N	-4.06690***	-4.28916***
Stationarity Tests of Variables on first Difference — Dickey-Fuller - GLS Test		
DLOILP	-4.87260****	-5.31464***
DLOILCON	-4.50875***	-6.06608***
DLy/N	-3.35399***	-3.703816**

Note:

1) The truncation lag for the PP tests is based on Newey and West (1987) bandwidth.

2) Critical values for Dickey-Fuller GLS test are based on Elliot-Rothenberg-Stock (1996, Table 1).

3) *** denotes 1% level of significance.

4) ** denotes 5% level of significance.

The results reported in Table 2 show that after differencing the variables once, all the variables were confirmed to be stationary. The Phillips-Perron and DF-GLS tests applied to the first difference of the data series reject the null hypothesis of non-stationarity for all the variables used in this study. It is, therefore, worth concluding that all the variables are integrated of order one.

4.6. Cointegration Test.
The cointegration relationship between OILP, OIL-CON and y/N is examined using the ARDL bounds testing procedure. Two steps are used in this procedure. In the first step, the order of lags on the first differenced variables in equations (1)-(3) is obtained from the unrestricted models using the Akaike Information Criterion (AIC) and the Schwartz-Bayesian Criterion (SBC). The results of the AIC and SBC tests (not reported here) show that while in the case of OILP and OILCON equations the optimal lag is lag 1, in y/N equation, the optimal lag is lag 3. In the second step, we apply bounds F-test to equations (1)-(3) in order to establish whether there exists a long-run relationship between the variables under study. The results of the bounds test are reported in Table 3.

Table 3. **Bounds F-test for Cointegration**

Dependent variable	Function	F-test statistics				
$\Delta Iny/N_t$	y/N (OILP, OILCON)	6.2529***				
$\Delta InOILCON_t$	OILCON(OILP, y/N)	1.8355				
$\Delta InOILP_t$	OILP(OILCON, y/N)	5.6898***				
Asymptotic Critical Values						
		1 %		5%		10%
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Pesaran et al (2001), p. 300, Table CI(ii) Case II		4.94	5.58	3.62	4.16	3.02	3.51

Note: *** denotes statistical significance at the 1% level.

The results reported in Table 3 show there is evidence of cointegration when y/N and OILP are taken as a dependent variable, but not when OILCON is taken as a dependent variable. This is supported by the calculated F-statistic, which is found to be statistically significant in both y/N and OILP equations but not in the OILCON equation.

4.7. *Analysis of Causality Test Based on Error-Correction Model.* Having found there is a long-run relationship between OILP, OILCON and y/N, the next step is to test for the causality between the variables used by incorporating the lagged error-correction term into equations (4) and (6). The causality in this case is examined through the significance of the coefficient of the lagged error-correction term and joint significance of the lagged differences of the explanatory variables using the Wald test. The results of the Granger causality test are reported in Table 4.

Table 4. **Granger non-causality test**

Dependent variable	F-statistics [P-value]			t - statistics
	$\Delta Iny/N_t$	$\Delta InOILP_t$	$\Delta InOILCON_t$	ECM $_{t-1}$
$\Delta Iny/N_t$	-	5.2655[0.0062]***	4.2879[0.0071]***	-0.4225** [-2.705]
$\Delta InOILP_t$	0.49135[0.6916]	-	6.4004[0.0008]***	-0.5919*** [-4.345]
$\Delta InOILCON_t$	1.4735[0.2386]	2.0416[0.1121]	-	-

The empirical results reported in Table 4 show there is a distinct short-run and long-run unidirectional causal flow from oil prices to economic growth. The short-run causality from oil prices to economic growth is supported by the F-statistics in the economic growth equation, which is statistically significant. The long-run causal flow, on the other hand, is supported by the lagged error-correction term in the economic growth function, which is negative and statistically significant — as expected. The results also show that oil consumption Granger-causes economic growth without any feedback. The short-run unidirectional causality from oil consumption to economic growth is supported by F-statistics, which is found to be statistically significant in the economic growth equation. The long-run causality, on the other hand, is supported by the coefficient of the error-correction term, which is negative and statistically significant in the economic growth function — as expected. The results,

however, fail to find any causality from either economic growth or oil prices to economic growth.

5. Conclusion. In this paper we examine the causal relationship between oil price and economic growth using data from South Africa. Previous studies on this subject had 3 major limitations. Firstly, the majority of the previous studies are based mainly on the cross-sectional data, which may not satisfactorily address the country-specific issues. Secondly, many previous studies are based largely on a bivariate analysis and may, therefore, suffer from the omission-of-variable bias. Finally, the majority of the previous studies mainly used cointegration techniques such as the residual-based cointegration approach by Engle and Granger (1987) and the maximum likelihood test by Johansen (1988) and Johansen and Juselius (1990), which may not be appropriate when the sample size is too small. In this study we incorporate the oil consumption in the bivariate causality model between oil price and economic growth — thereby creating a simple trivariate causality model. We also use the ARDL bounds testing approach to examine the cointegration relationship between oil prices, oil consumption and economic growth. Our empirical results show there is a distinct unidirectional causal flow from oil prices to economic growth in South Africa. Our results also show that oil consumption Granger-causes both economic growth and oil prices without any feedback. The results apply irrespective of whether the causality is estimated in the short run or in the long run. Given that the price of oil feeds directly into the general price level and the fact that South Africa has adopted inflation targeting as its policy anchor, we recommend that the monetary policy should be relaxed during the global oil price shocks in order to protect the country from any possible outcome of a full-blown stagflation scenario.

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