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# THE IMPACT OF OIL PRICE ON ECONOMIC GROWTH: TEST OF GRANGER CAUSALITY, THE CASE OF OECD COUNTRIES

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## ABSTRACT

Oil represents 40% of OECD countries s energy mix. Despite energy efficiency policies and programmes, these countries are still highly oil dependent. Oil price increase will have short run negative impacts long run damaging impacts on these economies. Hence the understanding of the mechanisms through which oil price affect the economic activity is important for policy makers in these countries as well as other net oil importing countries. The purpose of this paper is to investigate the granger causality between oil prices and economic growth using time series data between 1970- 2011. Based on this paper results, oil prices granger cause the economic growth in the short run but not in the long run. It also shows that economic growth dose not granger-cause oil prices neither in the short run nor in the long run.

**Keywords:** Economic growth, Oil price shocks, Aggregate supply, Aggregate Demand

## LIST OF ABBREVIATIONS

| | |
|---|---|
| **GDP** | Gross Domestic Product |
| **OECD** | Organisation for Economic Co-operation and Development |
| **VECM** | Vector Error Correction Model |
| **VAR** | Vector Autoregressive Regression |
| **AD** | Aggregate Demand |
| **AS** | Aggregate Supply |
| **SRAS** | Short Run Aggregate Supply |

  

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|---|---|
| **LRAS** | Long Run Aggregate Supply |
| **CPI** | Consumer price Index |
| **PPI** | Producer price Index |
| **MPC** | Marginal propensity to Consume |
| **CPI** | Consumer price Index |
| **ADF** | Augmented Dicey Fuller |

## 1. INTRODUCTION

During the last forty years oil was the main fuel of human civilization. The importance of oil as an energy source comes from two facts about this energy source characteristic the first one is that oil is unevenly distributed across the globe and the second is oil fluidity and heat content which attract large economies of scale. These characteristics have two min attributes for oil trade. The first oil trade has become the largest international tradable commodity all over the world. The second is that oil exploration, production and trade is highly sensitive to geopolitical circumstances.

However this high economic dependency on oil together with its geopolitical sensitivity resulted in one of the main attributes of oil trade and oil markets. That is the volatility of oil prices. This volatility threatens the stability of world economies and their sustainable growth and development. For this reasons economists believed that there is strong relationship between oil prices hikes and economic growth both in the short run and the long run.

The purpose of this paper is to investigate the granger causality between oil price and GDP in the net importer OECD countries during the period from 1970 to 2011. The paper will utilize the Vector Error Correction Model (VECM) in the environment of Vector Autoregressive Regression (VAR) to test this causality.

Based on the results of this paper oil prices granger the OECD GDP, between 1970-2008 only in the long run and the causality dose not found to exist the other way round.

## 2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The impact of oil prices increase in the economic activity could be understood using the aggregate supply (AS) Aggregate Demand (AD) model. If the AD/AS model is given by the equations below:

  

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$Y^d$= f (M/P, G, T, Z)..... (1)

$Y^s$= f (W/P, P/$P^e$, Z)..... (2)

} AS-AD Model

The AD curve (the plot of levels of quantity demanded of output and aggregate price level). The AS on the other hand reflects the quantity of output all firms in the economy are willing to supply at particular general level of prices. The AD for particular economy is driven for given amount of money supply and it slopes downward. Changes in money supply can shift this curve upward or inward. The increase in money supply pushes the AD upward and increases the output and vies versa. For the AS curve, because prices are sticky in the short run and flexible in the long run, AS is horizontal the short run and vertical in the long run.

The interaction between both AS and AD in the short and long run determines the economic stability, levels of output and employment. This AS/AD model could be used to understate fluctuations in the economy which are resulted from AD/AS shocks. Since oil price increase cause an AS shock, we can use this model to understand the channels through which oil price shock affects the economic activity in the short and long run. However the mechanism through which oil prices affects the economic activity could be shown in the following chart

  

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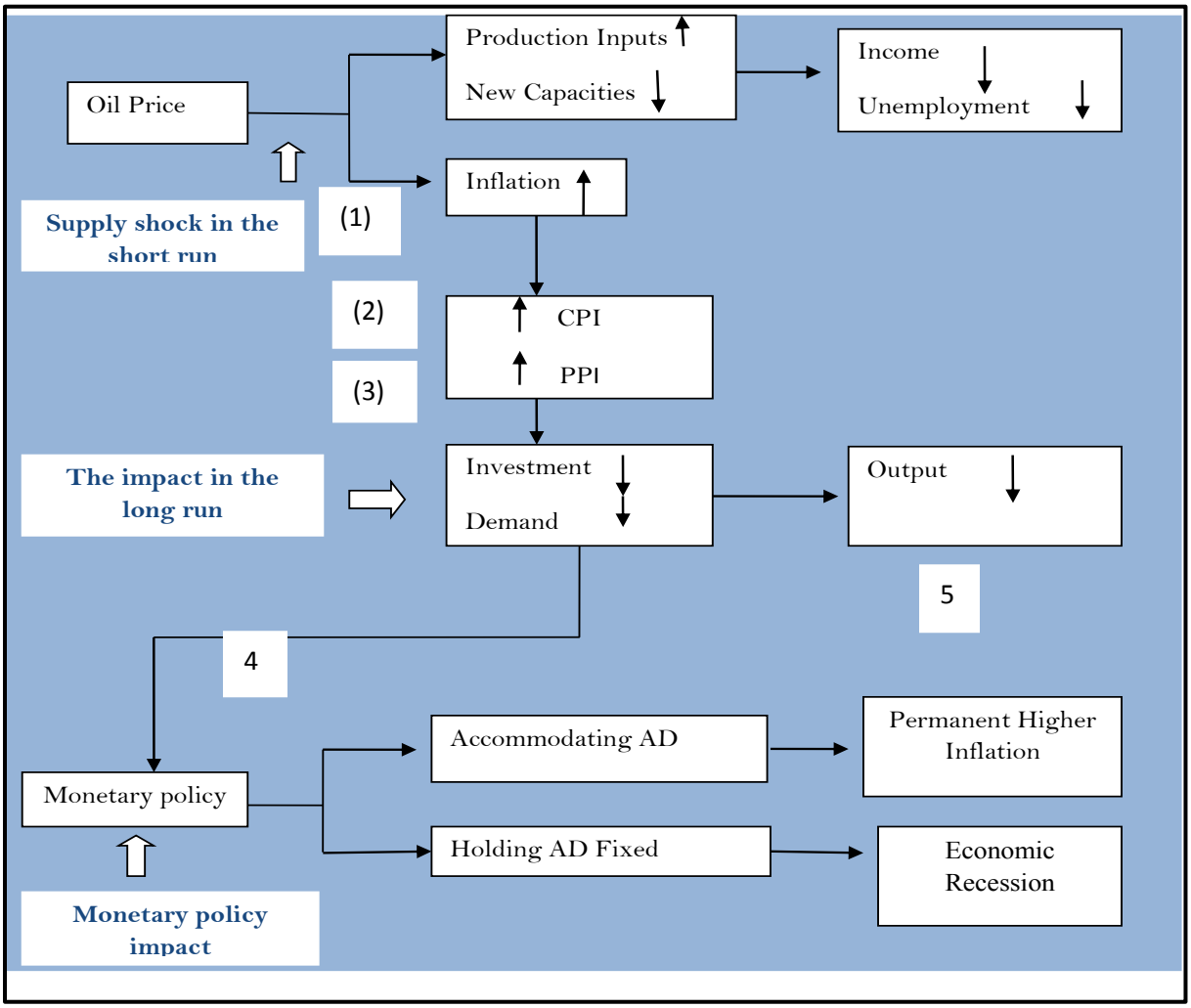


**Figure 1 Oil Price GDP Transitional Mechanism**

If we start from long run equilibrium of an oil importing country, point like A in the chart below, Other things being equal, an increase in oil prices will result in supply shock (1) in figure (). In the short run this supply shock will increase the cost of producing goods and services and hence postponing investment in new capacities and eventually reduce the output and employment and increase the general price level.

  

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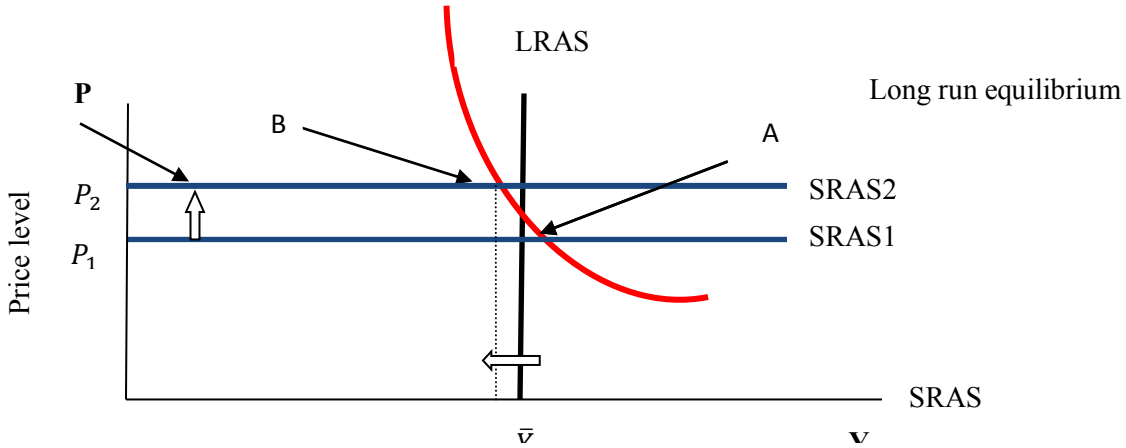


**Figure 2 Aggregate Supply Shock**

In the absence of monetary policy intervention, higher inflation rates will also increase the Consumer Price Index (CPI) due to the increase in cost of living and hence the economy will move to point B in the short run with higher inflation rates and lower output Higher levels of inflation will increase the Producer Price Index (PPI) point (£) in figure ().This increase will erode firm's profits and eliminate future investment which will ultimately shift the long run (vertical) aggregate supply to the left and reduce output point (4) in Figure ().

In such situation the monetary policy maker has to choose between two options point (5) in figure (). The first one is to keep the AD levels constant and hence both output and employment will be far away from the optimal levels. This policy over time will cause fall to restore full employment. The cost of this policy is painful economic recession. The second one is to expand AD through the increase of money supply this will push the AD upward and accommodate the AS shock. The economy will move directly from A to C in figure () and the final result of this policy is permanent higher price level. But it will keep levels of output and employment at its full employment rates. Hence oil price shock will result in either recession or permanent higher inflation rate.

  

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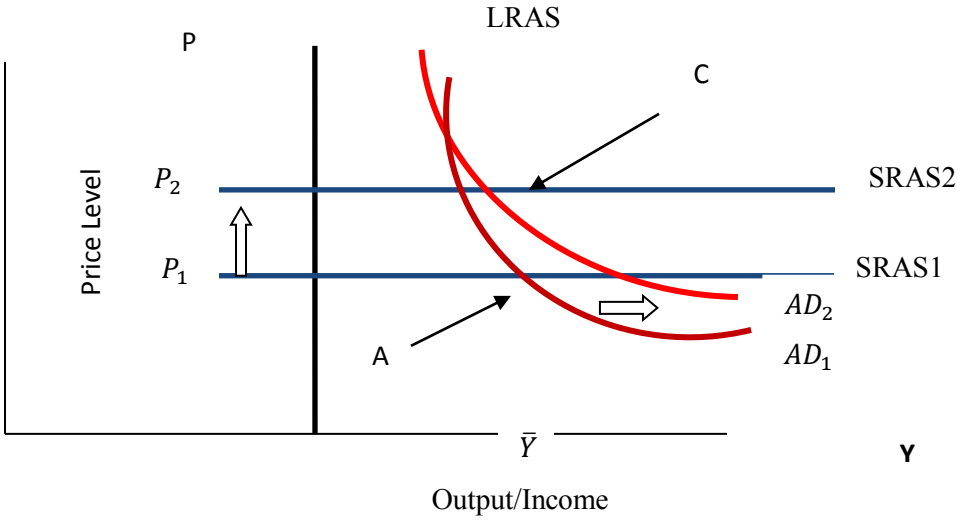


**Figure 3 the impact of monetary policy**

## 2.1 Literature Review

Lots of studies have examined the relationship between oil price and economic activity. The empirical studies tried to find out a significant negative relationship between the two variables.

The early studies were conducted by Rasche and Tatom (1981)1studied the impact of oil price increase on the USA economy between 1980 and 1986. The study found that oil price increase has negative impact on both the microeconomic and macroeconomic levels. It also showed that oil prices have symmetric effect on the macroeconomic variables.

Hamilton study (1983)2 , suggested strong relation between oil prices increased economic recessions in post-world war united State economy. Keane and Prasad (1996)3 find significant t relationship between oil price, output, employment and real wages. Later lots of studies investigated the existence of non-linear relationship between oil price and economic activity. And that the impact of oil prices is not only in the case price increase but also in the case of oil price decrease.

[1]Tantom J. A. *The macroeconomic Effects of Recent Fall in Oil Prices*, Federal Reserve Bank of ST. Louis,1987
[2]Ghalayani L., *The Interaction between Oil Price and Economic Growth*, Economic Department, Lebanese University,2011
[3]Hamilton D. J., *What is an Oil Shock*, Department of Economics, University of California, San Digo,1999

  

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However Jones and Leiby (1996)4in their study claimed that the relationship between oil prices and economic activity is asymmetric relationship and that this relation is more robust and significant in the case of oil price increase compared with oil prices decrease case. Also

Mork (1989), Leeet al (1995) and Hamilton (1996)5proved the existence of the non- linear relationship between oil prices and DP as well as the granger causality from oil price to GDP before 1973 and no granger causality form 1973 to 1994.

Recently, Gounder and Bartleet (2007) 6 prove both the linear and nonlinear links between oil price and economic activity. In models estimated for New Zealand economy. Further, as tudy by Jin (2008)7 shows that oil price increase has negative impact on the Japanese and Chinese economies and positive impact on the Russian economy.

## 3. OIL PRICE AND ECONOMIC ACTIVITY

On the empirical perspective the relationship between oil price and the GDP has been clearly noticed in more than one occasion. For instance Oil price increase in 1970 and 1976 coincided with decline in global economic growth and high level of inflation. Also the recent oil price increases also expressed the same impact in global economy. Economists attributes this mainly the increase in global oil demand, oil dependency and production oil intensity. Since during the period from 1970 to 2000 the global oil demand increased from46, 808 kbbl/d in 1970 to 84,337 kbbl/d.8

[4]Jonse W.D. and , Leiby N. P., *The Macroeconomic Impacts of Oil Price Shocks: A review of Literature and Issues*, energy division,Oak Ridge National Labrotory,1996

[5]Bouzaid A. ,*The relationship of oil prices and Economic growth in Tunisia A vector Error Correction Model Analysis*, Faculty of economic sciences, university of Tunis,2011

[6]Gounder R. and Bartleet M., *Oil Price Shocks and Economic growth Evidence for New Zealand 1989-2006*,Department of Applied International Economics, Massey University, 2007

[7]Jin G., *The Impact of Oil Price Shock and Exchange Rate volatility on the Economic Growth: a comparative Analysis for Russia ,Japan and China*, Graduate School of Economics, Osaka Prefecture University,2008

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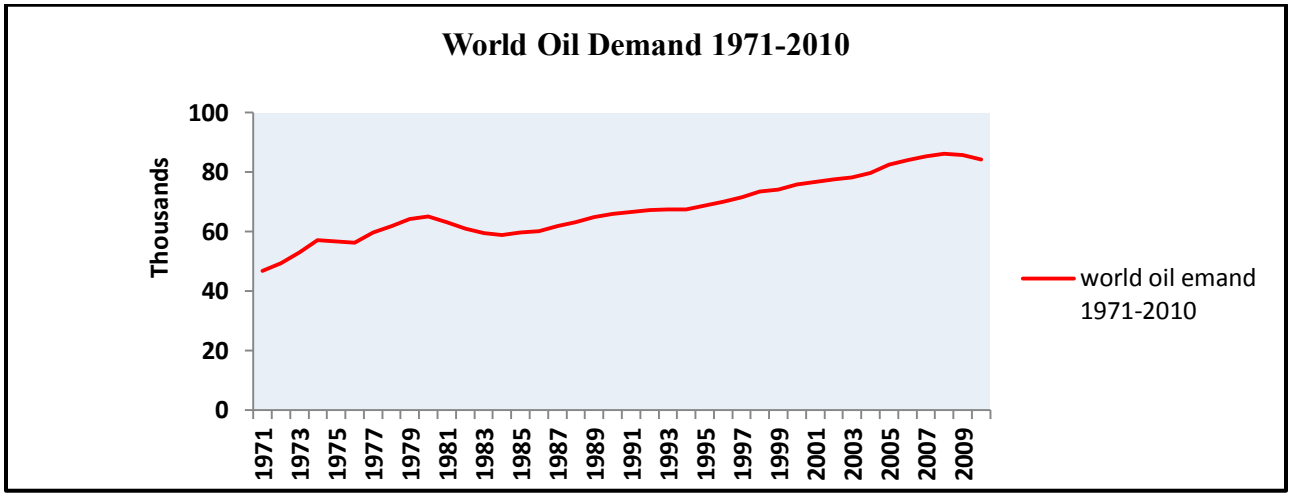


**Figure 4 World oil Demand**

Also the rates of oil dependency have increased from 1.0 in 1974 to 1.5 by 2000. Oil intensity also increased by 50% during this period. This high oil dependency coincided with continuous reduction in production by OPEC since 1980 which in turn resulted in oil price increase and volatility. Another factor affected the stability of oil prices is the increase of demand from emerging economies like China and India which put another pressures on the oil international price. Hence, the world faced highly uncertain and fluctuated oil prices which hugely affected the growth of almost all the economies.

For this reason the relationship between oil price and GDP has its strong conceptual appeal. But, whether oil prices can be used as one of the determinant variables for GDP growth or not is yet a controversial issue. Also the direction of the relationship between the two variables is another area of economic debate. The chart below reflects the trend of global economic growth and the oil prices between 1970 and 2011.

  

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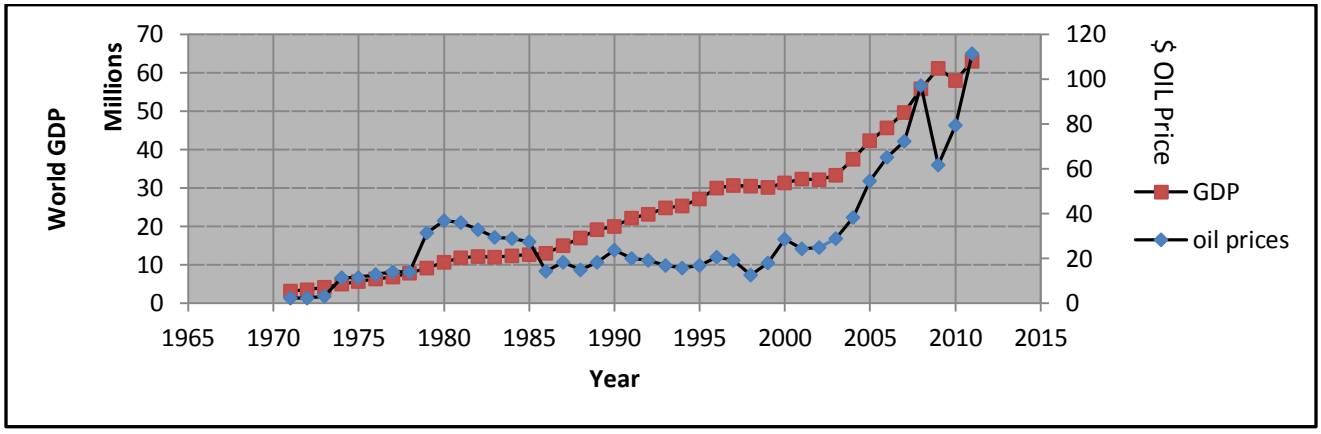


**Figure 5 World GDP and Oil Price**

This chart shows that both oil prices and global GDP are highly correlated. They have experienced an upward trend over the last 35 years. The chart also shows that the increase in oil prices is normally accompanied with the slowdown of world GDP; for example in 1980 and the reduction in oil prices coincided with an increase in world GDP for example the period between 1985 till 2000. Also the direction of the relationship between the two variables is another area of economic debate.

For the economist the direction of the relationship between oil prices and GDP is important for economic policy. However, both ideas are correct from the theoretical perspective. For instance the chart above tells us the gradual increase in global economy pushed oil prices up as more oil is demanded to fuel the growth in both developed and emerging economies between 1990 and 1995.

In 1998 the world growth decreased and the reduction in global economic growth lower the oil demand by all sectors in all economies which resulted in reduction in oil prices. Between 1999 and 2008 the sharp increase in global GDP led to huge increase in oil demand which resulted in oil price increase for m 35 to 100 in the first quarter in 2008 again the financial crisis and the reduction in global GDP drop down the prices. In the last quarter of 2008 the world economy absorbs the shock and started to recover prices started to increase again.

On the other hand the same behaviour of oil prices and GDP could be explained the other way round. The volatility of oil prices in the chart above could be used to interpret the behaviour of global GDP. Global recession was accompanied with oil prices increase.. This has been mainly noticed in 2000, 2004 and 2008 as could be seen in the chart above. Other things being equal the

  

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increase in oil prices will result in income transfer from oil importing countries to oil exporting ones. If this happen then the global economic growth will depend on marginal propensity to consume (MPC) in oil exporting countries. And because the MPC in exporting countries is less than that in the importing ones; always the increase in oil exporting countries economic growth will be offset by the reduction in the economic contraction in oil importing ones. Hence the ultimate result of oil price increase will be a reduction in global GDP.

### 3.1 The case in the OECD countries:

OECD countries except Canada and Norway are net imports. During the first and the second oil price shock the impact was much bigger but any price shock after 1985 resulted in relatively moderate impact in the OECD economies. This is due to number of reasons namely, the oil intensity of production has fallen dramatically between 1970 and 1985 see the chart below this mainly due to the adaptation of more efficient technologies of production, efficient use of oil and the movement to alternative energies like natural gas in power generation and the increase in the participation of less oil intensive industries in the GDP.

Despite this improvement in OECD countries ability to absorb oil price shocks; the adverse impact of oil price increase will continue even in the near future due to number of reasons. First the levels of oil consumption in the OECD countries during the period from 1970-2011 are almost sable there is no big decline in oil consumption. This is mainly due to the fact that oil represents 40% of most OECD countries primary energy supply9. However this pattern of oil dependence is not the same among all OECD countries. In fact, over the last 40years and particularly after the first oil shock the European countries have reduced their oil dependence form 45 % in 1980 to fewer than 40 % in the following years but this was not the case in North America till 1990s.

## 4. DATA SOURCES AND METHODOLOGY

The existence of causal relationship between oil price and GDP will be tested using granger causality test. This will be undertaken for the case of net oil importing OECD countries as a whole. Here if the exogenous variable is the cause of the indigenous variable, this means that the former will be useful in forecasting the latter. In other words, the explanatory variable is able to increase the accuracy of predicting the explained variable

In this paper the times series data of oil prices and OECD will be used to test the hypothesis of whether oil prices cause the GDP or vies versa. Thus there will be two VAR models taking the

[9]Barrel R. and Pomerantz O., *Oil Prices and World Economy*, NISER 2 Dean Street Smith Square, London SW1P 3HE, 2004

  

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GDP and the dependent variable in the first model and oil price as the dependent variable in the second one. Variables are expressed in logs. The acceptance and rejection of the null hypotheses will be determined depending on the significance of the f- statistics. The GDP /Oil price VAR models are:

$$Log(GDP_t) = c_1\, Log(p_{t-i}) + c_2\, Log(GDP_{t-i}) + u_{1t} \quad \text{..... (1)}$$

$$Log(P_t) = c_3\, Log(GDP_{t-i}) + c_4\, Log(P_{t-i}) + u_{2t} \quad \text{..... (2)}$$

The granger causality test is depending on two tests the unit root test and the co integration test. The stationary test will be conducted using the Augmented Dickey Fuller (ADF). The typical ADF model could be given in the following equation:

$$\Delta y_t = \alpha + \beta_t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \ldots + \delta_{p-1}\, \Delta y_{t-p+1} e_t \quad \text{..... (3)}$$

Where y is the variable under investigation, α is the constant, β is the coefficient on a time trend and p is the lag order of the autoregressive process.

The co-integration test examines whether oil price and GDP are sharing the same stochastic trend and will grow proportionally. According to Engle and granger if variables are co integrated then there will be a long run relationship between them and hence there must be either unidirectional or bidirectional causality between them. This test will be implemented using the Johanson-Juselius Multivariate co integration model. This model is given by the following equation:

$$\Delta X_t = \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-1} + \Pi X_{t-1} + \varepsilon_t \quad \text{..... (4)}$$

Where $x_t$ is the 2x1 vector of (GDP, Oil Price) respectively, $\Delta$ is the symbol of difference operator and $\varepsilon_t$ is a 2x1 vector of residuals. $\Gamma$ and Π are the short run and long run adjustment to changes in $x_t$. $\Pi X_{t-1}$ is the error correction term and Π can be factored into two separate matrices α and β such as Π =αβ', where β' denotes the vector of co-integrating parameters while α is the vector error correction coefficient measuring the speed of convergence to the long run steady state.

If oil price and GDP are found to be co –integrated then the Vector Error Correction Model VECM could be used to test the causality between the both. This VECM can have the following form.

$$\Delta \text{Log}\,(GDP_t) = \sum_{i-1}^{p-1} \beta_i\, \Delta Log\,(GDP_{t-1}) + \sum_{1-i}^{p-1} a_i \Delta\, Log(p_{t-1}) + z_1 EC1_{t-1} + \varepsilon_{1t} \quad \text{..... (6)}$$

  

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$$\Delta \text{ Log } (P_t) = \sum_{i-1}^{p-1} m_i \, \Delta Log \, (GDP_{t-1}) + \sum_{1-i}^{p-1} n_i \Delta Log(p_{t-1}) + z_2 EC2_{t-1} + \varepsilon_{2t} \ldots\ldots\ldots\ldots\ldots\ldots \text{ (7)}$$

Where, $\beta_i$ , $a_i$ ,$m_i$ and $n_i$ are the short run coefficients EC1and EC2 are error correction terms and $\varepsilon_{1t}$ and $\varepsilon_{2t}$ are residuals of the equations 3 and 4 respectively. $EC1_{t-1}$, is the lagged value of the residuals derived from the co- integrating regression of GDP on P, and $EC2_{t-1}$ is the lagged value of the residual s derived from the co integrating regression of p on GDP.

The unidirectional relationship from P to GDP (oil price granger cause GDP) will occur in equation 6 if the setoff estimated coefficients on lagged P coefficients are non- zero and this will be the short run causality. And the error correction coefficient $Z_1$ of $EC1_{t-1}$ is significant and this will be the long run causality.

Similarly the causality from GDP to P (GDP granger cause p) in equation7 will take place if the set of estimated coefficients on the lagged GDP $m_i$ coefficients are none zero this will be the short run causality. And he error correction coefficient $z_2$ of $EC2_{t-1}$ is significant and this will be the long run causality.

## 4.0 RESULTS AND ANALYSIS

### 4.0.1 Unit root test

Using the ADF model in equation 1 three models could be generated for each variable:

$$\Delta Y_t = \beta_1 + zY_{t-1} + a_i + e_t \quad \textbf{Intercept only..... (5)}$$

$$\Delta Y_t = \beta_1 + \beta_{2t} + zY_{t-1} + a_i + e_t \quad \textbf{trend and intercept..... (6)}$$

$$\Delta Y_t = zY_{t-1} + a_i + e_t \quad \textbf{no trend no intercept..... (7)}$$

  

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| variable | model | lags | ADF in level | ADF in difference |
|---|---|---|---|---|
| Log GDP | Trend and Intercept | 9 | -1.442099 | -4.4927995 |
| | none | | -1.676473 | -8.012450 |
| Log P | Trend and Intercept | 9 | -2.384451 | -6.025353 |
| | none | | - 1.334865 | -5.627277 |

**Table 1 Unit Root Test Results**

Based in the calculated ADF value presented in table 1 the null hypothesis of both variables cannot be rejected and they are non - stationary at level. But they are stationary if their first differences are taken.

### 4.0.2 Co- integration test

The Johansen co-integration test results of log GDP and log P showed that these two variables are co-integrated and have one co- integrating equation at level .05. This means that these variables have long run relation. And there is one error term in the model.

| Hypothesized No. of CE(s) | Eigen value | Critical Value @0.05 | Probability |
|---|---|---|---|
| None * | 0.385564 | 15.49471 | 0.0113 |
| At most 1 | 0.042343 | 3.841466 | 0.2058 |

**Table 2 Co Integration Test Results**

### 4.0.3 Causality test in the long run

The estimated VECM to test the causality from oil price to GDP (Oil price granger cause GDP in the long run) is given in the equation below:

**D(LOG_GDP) = C(1)*( LOG_GDP(-1) - 0.209105203577*LOG_P(-1) - 6.95265740045 ) + C(2)*D(LOG_GDP(-1)) + C(3)*D(LOG_GDP(-2)) + C(4)*D(LOG_GDP(-3)) + C(5)*D(LOG_GDP(-4)) + C(6)*D(LOG_GDP(-5)) + C(7)*D(LOG_P(-1)) + C(8)*D(LOG_P(-2)) + C(9)*D(LOG_P(-3)) + C(10)*D(LOG_P(-4)) + C(11)*D(LOG_P(-5)) + C(12).**

  

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The estimated VECM to test the causality from GDP to oil price (GDP granger-cause Oil price in the long run) is given in the equation below:

**D(LOG_P) = C(1)*( LOG_P(-1) - 4.78228175529*LOG_GDP(-1) + 33.2495666369 ) + C(2)*D(LOG_P(-1)) + C(3)*D(LOG_P(-2)) + C(4)*D(LOG_P(-3)) + C(5)*D(LOG_P(-4)) + C(6)*D(LOG_P(-5)) + C(7)*D(LOG_GDP(-1)) + C(8)*D(LOG_GDP(-2)) + C(9)*D(LOG_GDP(-3)) + C(10)*D(LOG_GDP(-4)) + C(11)*D(LOG_GDP(-5)) + C(12)**

The results for the long run causality could be shown in the following table.

| term | Ho | Observation | lags | F- statistic | Probability | decision |
|---|---|---|---|---|---|---|
| Long run | D(log oil price does not granger cause D(log GDP | 42 | 5 | -0.074890 | 0.0018 | H0 rejected |
| | D(log oil GDP dose not granger cause D(log P | 42 | 5 | 0.038218 | 0.5746 | H0 accepted |

**Table 3 Long run Causality test Results**

Based on the results above for the causal relationship form oil price to GDP, the f-statisticis negative and the p value is less than 5% so we can reject the null hypothesis i.e. Oil prices granger cause GDP in the long run.

### 4.0.4 The short run causality

To test the short run causality in the VECM we use the Wald test the results could be shown in the following table:

| term | Ho | Test statistics | value | probability | Decision |
|---|---|---|---|---|---|
| Short run | D (log P) does not granger - cause D (log GDP) | Chi-square | 4.185102 | 0.3815 | Ho Accepted |
| | D (log GDP) does not granger - cause D (log P) | Chi-square | 6.104825 | 0.1915 | Ho Accepted |

**Table 4 Short Run Causality Test Results**

Since the p-value of the Chai-square statistics is greater than 5% we cannot reject the null hypothesis i.e. there is no short run causality between from oil price to GDP G. In other words

  

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oil prices dose not granger-cause GDP in the short run. There is also no causal relation from GDP to oil prices in the short run.

### 4.1 Residuals Diagnosing Test:

The accuracy of the results above depends on the goodness of the two VECM to test this goodness number of test should be undertaken on the tow models residuals namely, the normality test, the serial correlation test and the hetrocidasctesty test. The results for these tests in the tow models are shown in the following table.

| Model | test | $H_0$ | Test | Statistics | Probability | Decision |
|---|---|---|---|---|---|---|
| **Oil price to GDP VECM** | Normality | Residual is normally distributed | Histogram | P-Value | 0.000007 | $H_0$ Rejected |
| | Heteroscedasticity | There is no arch effect in the model | Arch | Chi-Square | 0.8880 | $H_0$ Accepted |
| | Serial Correlation | The is no serial Correlation | BreuschGodfrey | Chi-Square | 0.0657 | $H_0$ Accepted |
| GDP to Oil **Price VECM** | Normality | Residual is normally distributed | Histogram | P-Value | 0.084481 | $H_0$ Accepted |
| | Heteroscedasticity | There is no arch effect in the model | Arch | Chi-Square | 0.9041 | $H_0$ Accepted |
| | Serial Correlation | The is no serial Correlation | Breusch Godfrey | Chi-Square | 0.1165 | $H_0$ Accepted |

**Table 5 Residuals Diagnosing Test Results**

According to the results in the table above although residuals in the first model are not normally distributed, yet we accept the model because there is no heteroscedasticity no serial correlation. For the second model the goodness of the model is very high since the results shows that residuals are normally distributed and there are no heteroscedasticity or serial correlation.

The above analysis could be summarised in the following:

- In the long run oil prices granger- cause GDP in OECD countries.
- In the short run oil prices dose not granger cause GDP in OECD countries

  

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- in the long run GDP dose not granger cause oil price
- In the short run GDP dose not granger cause oil prices in the OECD countries.
- There is unidirectional relationship between oil price and GDP so as oil price granger- cause GDP in the long run.

## CONCLUSION

Based on the analysis above the paper concludes that first there is co-integration between oil prices movements and economic activity in the OECD countries. The granger causality test showed that the relationship between oil price and GDP in the OECD countries is unidirectional relationship.

Oil price is found have negative impact on the GDP in the long run. With the relationship moves from oil price to GDP. The results also showed that the granger causality from oil price to GDP does not exist in the short run. This could be justified by the fact that OECD countries are highly dependent on oil. It also shows that oil price have minor impact in the short run but long run damaging impact on the long run economic growth in the OECD countries.

The analysis also shows that there is no causality form GDP of the OECD countries to oil prices, neither in the short run or in the long run. This could be justified by the fact that due to the energy efficiency policies that have been adapted in most to the OECD countries (European countries specially) the impact of the OECD growth now has less impact on the international oil price. Since OECD countered GDP has become less oil intensive. And the oil demand is almost flat in these countries since 1970.

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