The impact of real oil revenues fluctuations on economic growth in Algeria: evidence from 1960-2015 data

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The impact of real oil revenues fluctuations on economic growth in Algeria: evidence from 1960-2015 data [*]

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ABSTRACT

This paper investigates the impact of real oil revenues fluctuations on economic growth in Algeria using data from 1960 to 2015. To shed some new light on this question, we use a measure of real oil revenues recently developed by Gasmi and Laourari (2015) that is endogenous to Algeria's international trade structure. We apply the Johansen multivariate cointegration approach to analyze the short-run and the long-run dynamic relationship between real oil revenues and economic growth proxied by two variables, namely, real GDP and industrial sector growth. The cointegration analysis suggests that a long-run relationship exists between real oil revenues, real GDP, and industrial growth in Algeria. The impulse response function and the variance decomposition analysis suggest that the impact of unexpected shifts in real oil revenues on the country's economic and industrial growth is negative.

Keywords: Algeria, Real oil revenues fluctuations, Economic growth, Industrial sector, Time series.

JEL-codes: C32, O13, O14, Q32.

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1. INTRODUCTION

One of the most haunting questions in development economics is whether natural resource endowments promote or hamper economic growth and development. Indeed, oil revenues have enabled economic prosperity in many oil-exporting countries through large investments in infrastructure, human capital, and social services. However, many studies report that abundant natural resources may in fact be detrimental for the economy. This phenomenon, known as the resource curse, has come to be associated with any perverse consequence of a country's natural resource wealth on its social, political, and economic welfare.

The presumption that there exists a curse phenomenon steams from the observation that a great number of countries endowed with natural resources, most notably oil and gas, has failed to translate this economic asset into actual macroeconomic gains. In the contrary, these natural-resource-rich countries have often experienced, all things equal, lower economic growth rates than many of their natural resource-scarce counterparts. Moreover, these countries have developed at a slower pace, have often suffered structural disequilibria, and have been subject to social and political vulnerability.[1]

Algeria is the third largest oil-producing African country and the 17th largest oil producer in the world with a daily production capacity of 1.7 million barrel (U.S Energy Information Administration, 2015). This country has a proven oil reserve of about 12 billion barrels, the third largest reserve in Africa. Furthermore, in 2013, Algeria was ranked the eighth largest natural gas exporter in the world and the third largest gas supplier to Europe. Since the discovery of oil fields in Algeria in 1956, the oil sector has been the mainstay of this country's economy. Indeed, oil exports amount to 95 % of total exports and around two-thirds of government revenues (World Bank, 2016).

Although oil income has contributed to a large extent to Algeria's economic prosperity by providing the required financial resources for investment in other sectors, the country's overall economic performance and development have never reached their full potential levels. Examining whether oil revenues did actually help fostering economic development in Algeria is at the heart of the investigation

[1] An extensive review of the resource curse literature is beyond the scope of this paper. For further reading on this theory, see, for instance, Frankel (2012) and Stevens (2015).

conducted in this paper. More specifically, this paper uses a new measure of real oil revenues introduced by Gasmi and Laourari (2015), which accounts for the peculiar feature of Algeria's international trade structure when adjusting nominal oil revenues, and investigates the short-run and the long-run dynamic relationship between these revenues and the country's economic growth proxied by real GDP and industrial sector growth over the 1960-2015 period.

The remainder of this paper is organized as follows. The next section provides a brief survey of some related work. Section 3 describes the data used in the analysis. Section 4 gives an account of the empirical methodology utilized to assess the short-run and the long-run dynamic relationship between Algeria's real oil revenues and the country's economic growth. Section 5 reports the empirical results and section 6 concludes. The appendix contains some complementary material.

2. RELATED WORK

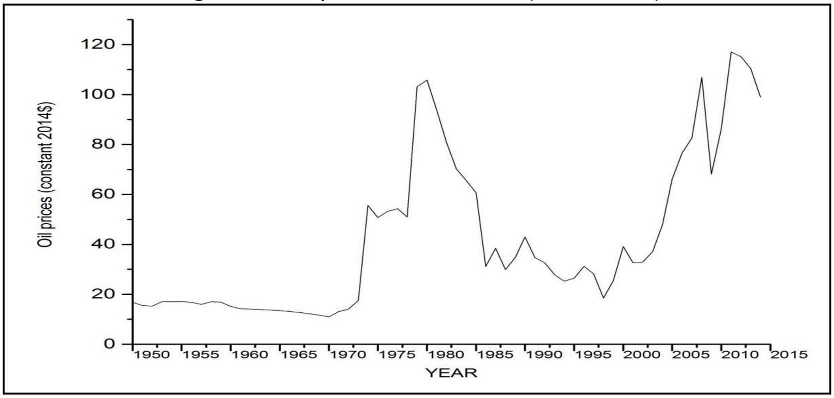
Economists have for long believed that an increase in oil prices, all else being equal, tends to have a positive impact on oil exporting countries. This is based on the idea that a boom in oil price creates a shift in terms of trade as income is transferred from importing to exporting nations, resulting in an increased national income. However, following a price rise, the exporting economies potential gains diminish because of the decreasing demand for oil from importing economies. For example, in 1984 when oil prices increased substantially, the demand for oil from importing countries has decreased and has caused economic recession (Pindyck, 1991). Hence, changes in oil price seem to not always have a positive effect on oil exporting countries, even when they lead to higher revenues. Instead, large fluctuations increase uncertainty in these countries, which is very likely to lower incentives for investment (Bernanke, 1983).

As pointed out by Hamilton (2013), over the years, oil demand has always fluctuated, and hence, oil prices just fluctuated as well.[2] Consequently, oil rich

[2] Hamilton (2013) identifies five main periods associated with significant changes in the price of oil, namely, 1859-1899, 1900-1945, 1946-1972, 1973-1996, and 1997 to present. Hamilton (2013) describes the latter two periods as "The age of OPEC" and "A new industrial age", respectively. Hamilton associates "the age of OPEC" with the move to a higher average real oil price, the change in the focus of the global oil market from North America to the Persian Gulf, and with authoritative behavior by OPEC. The "New industrial age" refers to the high levels of economic growth in the major emerging economies, in particular China and India.

countries that heavily rely on oil revenues as a major source of national income often face the price volatility issue. Figure 1 below plots oil price fluctuations over the 1950-2014 period in constant US dollars ($2014).[3] If a country's fiscal revenue is solely based on oil export revenues, then it is not unreasonable to think that its annual revenue would look just like the graph shown. Oil exporting economies are vulnerable to price volatility as they usually experience boost and bust cycles in which governments' level of expenditure varies with oil prices. Therefore, it becomes more challenging for these economies to plan ahead as uncertainty about future revenues seriously jeopardize long term planning, and they may become subject to costly reallocation of resources (Humphreys, 2007).

Figure 1- Oil price fluctuations, (1950-2014)



Since the 1970s, the oil-macroeconomy nexus has increasingly attracted researchers' attention. Initially, many empirical studies, mainly applied to the US economy, found a significant negative relationship between oil price shocks and economic growth. Hamilton's (1983) seminal study shows that oil price hikes are followed by decreases in output. He found a persistent negative correlation between oil price changes and GNP growth using US data for the period 1948-1972, and claimed that oil shocks were a contributing factor in at least some of the US recessions prior to 1972.[4] However, the conventional symmetric relationship

[3] The data used are extracted from BP Statistical Workbook (2015).

[4] Other studies have shown that this result extends to other variables including GDP (Hamilton, 2003), inflation (Bachmeier and Cha, 2011, Blanchard and Gali, 2009), monetary policy (Bachmeier, 2008, Bernanke *et al.*, 1997), current account deficits (Van Wijnbergen, 1985), the balance and terms of trade (Backus and Crucini, 2000), and employment and wages (Keane and Prasad, 1996).

between oil and economic activity has been questioned in Mork's (1989) seminal paper.

Mork (1989) provided empirical evidence to this asymmetry and showed that if the period under consideration was extended by including data from 1986 oil price plunge, the oil price-macroeconomy relationship, as established by Hamilton (1983), no longer holds. Mork's estimation results provided mixed evidence with real oil price increases being negative and highly significant, thus supporting Hamilton's conclusion, as opposed to real oil price decreases, which turned out to be positive though small and only marginally significant.

Following Hamilton's and Mork's papers, a vast theoretical and empirical literature has been devoted to the study of the linkages between oil price shocks and macroeconomic performance mostly in oil-importing developed countries. [5] However, over the last few years, the interest has switched toward oil-exporting developing countries and how unexpected changes in oil prices affect their macroeconomic performance. Table A.1 in the appendix presents the main papers that have investigated the symmetric and asymmetric impacts of oil shocks on economic performance of oil-exporting countries. These papers prove that it remains quite difficult to draw a clear-cut conclusion about the impacts of oil prices fluctuations on economic growth. The outcomes are different from an economy to another and empirical findings for developing countries vary more in the direction of the impact. Various econometric modeling specifications and different choice of variables could explain these varied results.

Regardless of the empirical approaches adopted, the literature seems to provide evidence that high volatility of resource revenues in resource abundant economies tends to harm the public sector and the external balance as they will face higher volatility that increases uncertainty and reduces investment and, with impeded implementation of a balance fiscal policy, retards economic growth. This study will examine the dynamic relationships between real oil revenues, economic growth and industrial sector growth in Algeria with a special interest in the responses of both economic and industrial sector growth to a shock in real oil revenues. The next section gives some details on the data used in this analysis.

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[5] See, for instance, Gisser and Goodwin (1986), Mork *et al.* (1994), Lee *et al.* (1995), Hooker (1996), and Lee *et al.* (2001).

3. DATA

The 1960-2015 time series used in this study include revenues from Algeria's real oil revenues (*ror*), Algeria's real GDP (*rgdp*), and Algeria's industrial sector growth (*indus*). Following Gasmi and Laourari (2015), we adjust the nominal oil revenues series by means of two indices in order to construct the *ror* series. The first index is an import-exponentially-weighted index that captures the effect of changes in the value of the US dollar against a basket of currencies of Algeria's main import partners. The second index is also based on the same weighting procedure and accounts for inflation passed through imports from these partners to the Algerian economy. The bulk of the data were obtained from the Algerian Office National des Statistiques (ONS), the International Monetary Fund (IMF), the Organization of Economic Cooperation and Development (OECD), the World Bank (WB), and the United Nations (UN). More details on these data and their sources are given in the appendix.

4. EMPIRICAL METHODOLOGY

This section discusses the empirical strategy adopted in this study. We describe the empirical approach used to analyze the long-run relationships between Algeria's real oil revenues, industrial growth and economic growth over the last for decades.

The investigation of the dynamic relationships requires determining the order of integration of the times series data under consideration. If a series is stationary, it is said to be integrated of order zero or I(0), and if it is not stationary in its level form but stationary in its first differenced form, it is said to be integrated of order one or I(1). In this paper, we conduct a series of unit root tests, namely, Augmented Dickey Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS).[6]

We then proceed to the analysis of the dynamic relationships between the country's real oil revenues and both overall economic and industrial growth using annual data for the 1960-2015 period. For this purpose, we run regressions involving the variables real oil revenues, *ror*, industrial growth, *indus*, and real GDP, *rgdp*,

[6] A detailed description of the properties and the econometric specification of each of the three conducted unit root tests are beyond the scope of this study. For a comprehensive presentation and further discussion, see Maddala and Kim (1998).

taken in their natural logarithms.[7] There are, of course, many macroeconomic variables that affect economic growth and may equally be considered beside oil revenues and industrial growth. Although, as is well known including such variables into the specification would likely improve the goodness-of-fit of the model, the drawback is that it would decrease the number of degrees of freedom, which is equal to the number of observations minus the number of parameters to estimate. Given the size of our sample and that we have already accounted for the effects of the real exchange rate changes and the variations in inflation when calculating the adjusted nominal oil revenues series, we have decided to restrict the model to only these three variables.

We proceed to specify the baseline empirical model to be used for testing the hypothesized relationship among the three core variables under investigation. We set

$$rgdp_t = \delta_0 + \delta_1 ror_t + \delta_2 indus_t + \varepsilon_t \qquad t = 1, 2, \ldots T \tag{1}$$

where δ_0, δ_1, and δ_2 denote respectively the unknown intercept and slope parameters to be estimated and ε_t is the disturbance term assumed to be purely random.

The vector autoregressive (VAR) model is a flexible model for the analysis of multivariate time series and it is particularly useful for describing the dynamic behavior of macroeconomic time series (Juselius, 2006). Because of these characteristics, the VAR and the vector error correction model (VECM) approaches have been widely used in the literature. Along these lines, to estimate the model given in equation (1), we use the Johansen cointegration technique (Johansen and Juselius, 1990). This technique involves three steps. First, we investigate whether all the variables in the model are integrated of the same order through unit root tests. Second, we determine the optimal lag length for the VAR model to verify that the estimated residuals do not suffer from autocorrelation. Third, we estimate the VAR model and construct the cointegration vectors to determine the order of

[7] Besides minimizing the effect of outliers, the natural logarithm transformation lessens any potential problems of heteroskedasticity.

cointegration that is necessary to perform the trace and the Max-Eigen value tests statistics.

We start the long-run analysis by examining the time series properties of all the variables included in equation (1). We determine the order of integration of each series by conducting the three unit root tests, namely, the ADF test, the PP test, and the KPSS test. All I(1) series are then considered as first differenced stationary and the variables are said to be cointegrated if a linear combination of them is stationary at level I(0). The existence of a cointegrating relationship means that a long-run equilibrium relationship exists among the co-integrated variables.

In order to specify the models to estimate, we begin with the following simple VAR framework with *k* lags in the tradition of Sim (1980):

$$Y_t = \mu + \sum_{i=1}^{k-1} \phi_i Y_{t-i} + \varepsilon_t, \qquad t = 1, 2, ..., T \tag{2}$$

where Y_t is an $(n \times 1)$ vector of variables of interest, μ is an $(n \times 1)$ vector of intercept terms, ϕ_i is an $(n \times n)$ matrix of coefficients, and ε_t is an $(n \times 1)$ vector of *i.i.d.* spherical error terms.

We then derive a typical VECM in its simplest form as developed by Johansen (1988) written as follows:

$$\Delta Y_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-1} + \varepsilon_t, \qquad t = 1, 2, ..., T \tag{3}$$

where Δ is the first-difference operator, Γ_i is an *n*-dimensional square matrix of coefficients that contains information regarding the short-run relationships among the variables, Π is an $(n \times n)$ matrix of coefficients decomposed as $\Pi = \alpha\beta'$ where α and β are $(n \times r)$ adjustment and cointegration matrices, respectively. We further specify the VECMs for our analysis as following:

$$\Delta rgdp_t = \alpha_0 + \alpha_1 \Delta rgdp_{t-1} + ... + \alpha_k \Delta rgdp_{t-k} + \beta_1 \Delta ror_{t-1} + ... + \beta_k \Delta ror_{t-k}$$
$$+ \delta_1 indus_{t-1} + ... + \delta_k indus_{t-k} + \gamma ECT^1_{t-1} + \varepsilon_t \tag{4}$$

$$\Delta ror_t = \alpha_0 + \alpha_1 \Delta rgdp_{t-1} + ... + \alpha_k \Delta rgdp_{t-k} + \beta_1 ror_{t-1} + ... + \beta_k ror_{t-k}$$
$$+ \delta_1 indus_{t-1} + ... + \gamma ECT^2_{t-1} + \varepsilon_t \tag{5}$$

$$\Delta indus_t = \alpha_0 + \alpha_1 \Delta rgdp_{t-1} + ... + \alpha_k \Delta rgdp_{t-k} + \beta_1 \Delta ror_{t-1} + ... + \beta_k \Delta ror_{t-k}$$
$$+ \delta_1 indus_{t-1} + ... + \delta_k indus_{t-k} + \gamma ECT^3_{t-1} + \varepsilon_t \tag{6}$$

where $ECT^1_{t-1}, ECT^2_{t-1}, ECT^3_{t-1}$ are the vector error correction terms in each equation and k is the optimum lag length determined by the lag selection criteria.

The next important step is to determine the optimal lag length as the Johansen test is very sensitive to the lag length employed in the VECM. We conduct a pre-test by entering variables in levels into VAR models with different lag lengths and we employ F-tests to select the optimal number of lag lengths needed in the cointegration analysis. To determine this optimal lag length, we rely on three classical criterions, which are the Akaike information criterion (AIC), the Schwarz criterion (SC), and the likelihood ratio (LR) criterion.

We then proceed to determine the number of long-run relationships between the variables of interest, i.e., the number of cointegrating vectors. The Johansen procedure uses two tests to determine the number of cointegrating vectors, which are the trace test (λ_{trace}) and the maximum eigenvalue test $(\lambda_{\max})$.[8] In the trace test, the null hypothesis is that the number of cointegrating vectors is less than or equal to r, with r = 0,1,2. In each case the null hypothesis is tested against the general alternative. The maximum eigenvalue test is similar, except that the alternative hypothesis is explicit. The null hypothesis r = 0 is tested against the

[8] The trace test is based on the statistic $\lambda_{trace} = -T \times \sum \ln(1 - \hat{\lambda}_i)$ and the maximum eigenvalue test on the statistic $\lambda_{\max} = -T \times \ln(1 - \hat{\lambda}_{r+1})$, where *k* is the number of variables in the system, *T* is the number of observations, and $\hat{\lambda}$ are the estimated eigenvalues (Johansen, 1995).

alternative $r = 1$ and the null hypothesis $r = 1$ is tested against $r = 2$. In some cases the maximum eigenvalue statistic and the trace statistic may yield different results. If there is any divergence of results between these two tests, it is preferable to rely on the evidence based on the maximum eigenvalue test because it is more reliable in small sample (Odhiambo, 2005, Mukhtar and Rasheed, 2010).

The VECM allows us to capture both the short-run and long-run relationships. The existence of a cointegration between variables implies that causality exists in at least one direction between the variables in the model (Engle and Granger, 1987). Hence, after establishing the number of cointegrating vectors and estimating our model, we can determine the direction of Granger causality between the variables *rgdp*, *ror*, and *indus*. The short-run Granger causality can be established by conducting a joint test of the coefficients in the VECM on the basis of an F-test and a χ^2 test, whereas the long-run causal linkages are implied by the significance or not of the t-statistic of the lagged error-correction terms that contain the long-term information since it is derived from the long-run cointegrating relationships.

Before proceeding to the IRFs and VDCs analysis, we check for the efficiency and the consistency of the VECM specified in equations (4), (5), and (6) by performing some robustness diagnostic tests. First, we perform the Jarque-Bera test which is a goodness-of-fit test of whether sample data have the skewness and kurtosis matching a normal distribution (Jarque and Bera, 1980). Second, we test for the presence of autocorrelation by conducting the Lagrange Multiplier (LM) test proposed by Breusch and Godfrey (1981), which is a multivariate test statistic for autocorrelation in residuals up to the specified lag order. Third, we conduct the White test for heteroscedasticity proposed by White (1980) to ensure that the residuals are homoscedastic, i.e., that they have a uniform variance. We also check for the stability conditions of the specified VECM. If the estimated VECM is stable, then the inverse roots of the characteristics Autoregressive (AR) polynomial will have a modulus (absolute value) less than one and lie inside the unit circle (Lütkepohl, 2005).

We compute IRFs in order to examine the dynamic properties and interactions between the variables in the estimated model. IRFs analysis tracks the responsiveness of a particular variable's shock on the other variables that are included in the model. In our study, we examine the dynamic behavior of the times series in this study over a twenty-year forecast horizon. We choose to conduct the generalized IRF (Koop *et al.*, 1996; Pesaran and Shin, 1998) to investigate the impacts and responses of the shocks, in favor of the more traditional orthogonalized approach. The reason for doing so is that the results of the orthogonalized approach are sensitive to the ordering of the variables in the VECM system, a shortcoming that the generalized approach does not possess.

In addition to IRFs, we generate twenty-year horizons VDCs that offer a slightly different method for examining the dynamic interaction among the variables. It measures the percentage of the forecast error of a variable that is explained by another variable. More specifically, it indicates the relative impact that one variable has on another variable. At the same time, it provides information on how a variable of interest responds to shocks or innovations in other variables (Bessler and Kling, 1985). Thus, in our context, it allows us to explore the relative importance of Algeria's real oil revenues in accounting for variations in overall economic growth and industrial growth. To interpret the economic implications from VDCs findings, we employ the Sim's (1980) innovation accounting procedure. This procedure involves the decomposition of the forecast error variance of each variable into components attributable to its own innovations and to shocks of other variables in the system.

5. EMPIRICAL RESULTS AND DISCUSSION

This section discusses the empirical results obtained in this study. The results of unit root tests for the variables of interest in levels and in first differences are reported in Table 1 below. The results show that unit root tests applied to all the variables in levels fail to reject the null hypothesis of the variables being non-stationary. The null hypothesis of the variables being non-stationary is rejected when the series are taken in first differences, which says that all variables are first-differenced stationary. Consequently, all the series are I(1), i.e., integrated of order one.

We next investigate the existence of any unique equilibrium relationship(s) among the stationary variables of the same order of integration. As discussed in the previous section, the Johansen methodology is a VAR-based approach the results of which are generally found to be sensitive to the selection of the lag structure. The optimal lag length for our cointegration analysis was chosen by minimizing the AIC and the SBC information criteria. The selected lag length is the one that reduces autocorrelation in the model and both of these criteria have suggested an optimal lag interval of (1,2).

Table 1- ADF, PP and KPSS unit root tests results+

Series in levels			
Variable	(ADF-statistic, Lag)	(PP-statistic, Lag)	(KPSS-statistic, Lag)
rgdp	(-1.405, 2)	(-0.874, 3)	(0.153, 3)
ror	(-0.326, 1)	(-0.155, 3)	(0.148, 3)
indus	(-1.261, 1)	(-1.493, 3)	(0.246, 3)
Series in first differences			
rgdp	(-9.092*, 1)	(-9.416*, 3)	(0.092*, 3)
ror	(-7.573*, 0)	(-7.662*, 3)	(0.064*, 3)
indus	(-6.835*, 0)	(-6.852*, 3)	(0.110*, 3)

+ A "*" attached to a value of the ADF- or the PP-statistic indicates a rejection of the null hypothesis H_0 that the series is a unit root process, in which case it is not stationary, at the 5% statistical significance level. A "*" attached to a value of the KPSS-statistic indicates a no rejection, at the 5% significance level, of the null hypothesis, H_0, that the series is stationary against the alternative hypothesis, H_1, that it is a unit root process.

A cointegration relationship among the variables *rgpd*, *ror* and *indus* has been investigated using the Johansen-Juselius technique. The cointegration test includes assumptions that allow for a linear deterministic trend in the data and intercepts in both the cointegrating equation and the VAR test.[9] Table 2 below reports our cointegration test results based on Johansen's maximum likelihood method. Both the trace and maximum eigenvalue test results reveal that there is at least one cointegrating vector among the variables *rgdp*, *ror*, and *indus*. We can reject the null hypothesis of no cointegrating vector in favor of one cointegrating vector with both tests at a 5% level of significance. We also cannot reject the null hypothesis of at most one cointegrating vector against the alternative hypothesis of two cointegrating vectors, for both the trace and maximum eigenvalue tests. Thus, we can conclude that there is only one cointegrating relationship among *rgdp*, *ror*, and *indus*. This leads us to conclude that there exist a long-run relationship between real oil revenues, economic growth, and industrial sector growth in Algeria.

[9] The series may have nonzero means and deterministic trends as well as stochastic trends. Similarly, the cointegrating equations may have intercepts and deterministic trends. Johansen (1995) discusses five deterministic trend cases.

Table 2- Johansen-Juselius cointegration test results+

Hypothesized No. of CE(s)	Trace statistic	Max-Eigen Statistic	Critical values (5%) Trace	Max-Eigen
None	41.961	27.889	34.91	22.00
At most 1	14.072*	9.679*	19.96	15.67
At most 2	4.393	4.393	9.42	9.42

Cointegrating coefficients normalized on *rgdp*:

rgdp = -3.746 - 0.303*ror* + 0.452*indus*

(-4.38) (7.21)

+ A "*" attached to a value of the Trace or the Max-Eigen value indicates a rejection by the test of the null hypothesis of r = 0 at the 5% statistical significance level, and t-statistic values are reported in parenthesis below the normalized coefficients.

The cointegrating equation, which is given at the bottom of the Table 2, has been normalized for *rgdp*. As all variables are in logarithmic form, we may interpret the coefficients as elasticities. Looking at the results, the normalized cointegrating equation reveals that, in the long run, the real purchasing power of oil revenues negatively affects economic growth in Algeria. More precisely, a 1% increase in the real purchasing power of oil revenues leads to a 0.30% decrease in the country's economic growth within the context of the long-run horizon. This negative impact of real oil revenues on growth is highly significant when judged by the t-statistic. In a similar vein, the normalized cointegrating equation also shows that the industrial sector growth positively affect economic growth in Algeria. More specifically, a 1% increase in the industrial sector growth leads to a 0.45% increase in the country's overall growth, again over the long-run horizon. This positive impact is also significant as can be seen from the value of the t-statistic. Interestingly, the results seem to suggest that changes in Algeria's economic growth are more elastic, i.e., more responsive to changes in the industrial sector growth than to changes in real oil revenues.

Having established that all variables in the model are I(1) and cointegrated, a VECM with one cointegrating relation and one lag in each equation has been estimated. Table 3 below reports the estimated short-run coefficient estimates. As previously discussed, the VECM allows for the long-run behavior of the endogenous variables to converge to their long run equilibrium relationship while allowing for a wide range of short-run dynamics. The error correction term captures the disequilibrium situation. A negative and significant coefficient of this error term suggests that there is a short-run adjustment process working behind the long-run equilibrium relationship among the variables. This indicates that the system is stable and that it convergences to an equilibrium path in case of any occurrence of a disturbance in the system.

Table 3- Estimated short-run coefficients of the VECM +

	Δ*rgdp*	Δ*ror*	Δ*indus*
Constant	0.034	0.133	0.020
ECT_{t-1}	-0.068*	-0.573*	0.125*
t-statistics	-5.12	-3.46	1.98
R-squared	0.52	0.47	0.37
Adjusted R-squared	0.44	0.38	0.27

+ A "*" denotes statistical significance at the 5% level, Δ refers to the first difference operator, and ECT_{t-1} is the error correction term.

We can see from Table 3 above that the coefficient of the ECT of the variable *rgdp* carries the correct sign and is statistically significant at 5% level, and that the speed of convergence to equilibrium is 7%. Hence, Algeria's real GDP is adjusted by 7% of the past year's deviation from equilibrium in the short run. A somewhat large absolute value of the ECT coefficient means that agents remove a large percentage of disequilibrium in each period, i.e., the speed of adjustment is very rapid. In contrast, a low absolute value indicates a slow speed of adjustment towards equilibrium. In view of the results, we thus can say that the speed of adjustment of real GDP towards equilibrium is slow. The coefficient of the ECT of the variable *ror* has a negative sign and it is significant at a 5% level. We see that Algeria's real oil revenues deviations from the short run to the long run are corrected by 57% per year. The speed of adjustment of these revenues toward equilibrium is faster than that of real GDP. The coefficient of ECT of *indus* variable has positive sign and it is statistically significant at 5% level. This means that due to any disturbance in the system, divergence from equilibrium will take place and the system will be unstable.

The VECM contains crucial information on causal relationships and the dynamic interactions among the variables included in the model. The existence of cointegration and the significance of the error correction terms coefficients for each time series clearly suggests the existence of a causal relationship in at least one direction among the cointegrating variables. In order to analyze the short-run causal relationships among *rgdp*, *ror* and *indus* for each equation in the VECM, we consider χ^2 (Wald) statistics for the significance of the lagged endogenous variables in that equation. The results of the Granger causality based on VECM are presented in Table 4 below. They indicate the presence of a unidirectional short-run causality running from *ror* to *indus*. All other combinations failed to demonstrate evidence of causal relationship in any direction. The significance of the error correction term for changes in each variable means that a long-run causality running from *ror* and *indus* to real GDP exists in the Algerian data.

Table 4- Granger causality based on VECM [+]

Dependent variable	Δ*rgdp*	Δ*ror*	Δ*indus*	ECT_{t-1}
		χ^2 (p-value)		t-statistics
Δ*rgdp*	-	0.655	0.526	-0.068*
Δ*ror*	0.251	-	0.395	-0.573*
Δ*indus*	0.137	0.026*	-	0.125*

[+] A "*" denotes statistical significance at the 5% level, Δ refers to the first difference operator, and ECT_{t-1} is the error correction term.

Prior to estimating and interpreting the IRFs and VDCs, we need to investigate the robustness and the stability of the estimated VECM model. We applied a series of diagnostic tests on the residuals. The residuals must be normally distributed, with no serial correlation and heteroscedasticity in order to ensure efficiency of the estimators. Table 5 below outlines the outcomes of diagnostic tests for normality, serial correlation and heteroscedasticity. The normality test of Jarque-Bera shows that the residuals have a normal distribution. The results also indicate that the residuals, tested up to 10 periods delays, have no serial correlation. Moreover, they do not suffer from heteroscedasticity problems.

We check the stability conditions of the estimated VECM to see whether the number of cointegrating equations is correctly specified. Figure A1 in Appendix A shows the inverse roots of the AR characteristic polynomial. We can see that no roots of the characteristic polynomial lie outside of the circle and hence, our estimated VECM model satisfies the stability conditions. The diagnostic results do not seem to indicate that our model is misspecified, and thus, we can safely proceed to the analysis of the IRFs and VDCs.

Table 5- VECM diagnostic tests+

Diagnostic test	H_0	df	p-value
VEC Residual Normality Tests	Residuals are normally distributed	6	0.246
VEC Residual Serial Correlation LM Tests	No serial correlation at lag order *h*	9	>0.05
VEC Residual Heteroscedasticity Tests	Residuals are homoscedastic	84	0.472

+ The acronym "df" indicates the number of degrees of freedom and a p-value greater than 0.05 indicates a rejection of H_0 at a 5% significance level.

In order to capture the responsiveness of a series in the presence of a shock in one of the variable beyond the selected time period we used the Generalized IRFs. A total of nine impulse responses could be calculated since there are three variables in the system. However, in our context, we only present and discuss the results regarding the responses of both real GDP and industrial growth to a shock in real oil revenues. These results are presented in Figure A2 of Appendix A. This figure suggests that the shock induced by *ror* has an immediate effect, which leads to a decrease in *rgdp* in the short run. The larger negative impact occurs in the second period and is followed by a gradual decrease over the following periods until the last forecast year. At the twentieth period, the impact of a shock in *ror* is about 4%. We also see from Figure A2 that a shock in *ror* has an instantaneous negative impact of about 7% on *indus* that lasts, although decreasing, until the end period.

We now proceed to analyze the relative importance of Algeria's real oil revenues in accounting for changes in real GDP and industrial growth. Table 6 below shows the VDCs for the three variables of interest estimated over twenty year forecasting horizon. We again recall here that the essence of the VDC is that it measures the proportion of forecast error variance in one variable explained by innovations in itself and in the other variables. The higher the share of the explained error variance, the more important the variable compared to other variables in the system.

The results of the VDCs show that nearly 92% of the real oil revenues variance is explained by its own shocks in the first year, and then it declines to about 86% in the twentieth year. Similarly, we observe that most of the variations in each of the *rgdp* and *indus* series are due to their own innovation. Not much of the variations in the real GDP are explained by innovations in real oil revenues. Rather, it takes some time after the shock for the real oil revenues to have an impact on real GDP. The results clearly indicate that a shock in real oil revenues exerts no impact on real

GDP in the first forecast year. After the first five years, real oil revenues account for only 7% of the variations in real GDP and for roughly 24% in the last forecast period. Immediately after the shock, real oil revenues contribute by about 24% to variation in industrial growth. However, the effect increases over time to reach 39% in the last forecast period. Interestingly, the results show that from the fifth period onwards, real oil revenues shocks have a greater impact on real GDP with variances ranging from 7% to 24%.

Table 6- Variance decomposition

Dependent variable	Time horizon (year)	*rgdp*	*ror*	*Indus*
	1	100.00	0.00	0.00
	5	79.32	6.99	13.68
rgdp	10	67.76	14.98	17.28
	15	60.87	20.39	18.73
	20	56.64	23.85	19.49
	1	7.79	92.20	0.00
	5	11.10	87.63	1.26
ror	10	11.67	87.04	1.28
	15	11.89	86.65	1.44
	20	12.03	86.34	1.62
	1	4.90	24.18	70.91
	5	9.60	46.82	43.56
indus	10	11.07	44.40	44.51
	15	11.91	41.57	46.50
	20	12.48	39.39	48.11

What implications can be drawn from the empirical findings that we discussed in this section? First, the existence of a negative and significant long-run relationship between the real oil revenues and economic growth seems to provide evidence in support of the resource curse hypothesis in Algeria, or at least, it indicates that the assumed positive effects of oil revenue streams on the country's economic performance cannot be taken for granted. Higher nominal oil incomes, which in fact are not that high in real terms considering the persistent loss in their real purchasing power (Gasmi and Laourari, 2015) appear to act as an obstacle for long-run growth in Algeria. The impact of the real oil revenues fluctuations on Algeria's economic growth in the short run has, however, turned out to be insignificant. We found no evidence of a short-run causality nexus between these revenues and real GDP and both IRFs and VDCs results also support the evidence of a small effect of real oil revenues shocks on economic growth in the short-run (< 5 years). This clearly indicates that shocks in real oil income, ceteris paribus, are neither necessary nor sufficient to explain the changes in the country's real GDP.

Second, the existence of a positive and significant long-run nexus between the industrial growth and Algeria's real GDP is in line with the vast literature that provides evidence about the industrial sector being one of the main driving forces for structural change and economic development. An interesting observation that our results allow us to make is that the IRF and VDC industrial growth reaction to unexpected movements (shocks) in real oil revenues are both negative. These findings are further corroborated by the existence of a short-run causal relationship running from real oil revenues to industrial growth. This may provide a piece of evidence in support of the Dutch disease hypothesis in the case of Algeria.

6. CONCLUSION

This paper sought to examine the short-run and the long-run dynamic relationship between Algeria's real oil revenues fluctuations and this country's economic growth as proxied by two variables, namely, real GDP growth and industrial sector growth by means of the Johansen multivariate cointegration approach. The analysis suggests that a long-run dynamic relationship exists between real oil revenues, real GDP growth, and industrial growth in Algeria. The impulse response function and the variance decomposition analysis suggest that the impact of unexpected shifts in real oil revenues on the country's economic growth and industrial growth is negative.

Two main conclusions can be drawn from the results obtained in this study. First, Algeria is extremely vulnerable to the negative consequences of oil price drops and faces a real challenge in reducing its dependence on volatile oil revenues by enhancing these revenues' management in a way that ensures the country's economic sustainability mostly through the diversification of income sources. Moreover, despite being a significant source of the government income, Algeria cannot endlessly rely on an exhaustible natural resource to fuel its economy, especially considering that the oil sector is not labor-intensive, and thus, that it does create only few jobs.

Second, it appears that the mere existence of oil endowments in Algeria is neither a blessing nor a curse, and the country's poor economic performance can be explained by some other factors. A large body of the oil-development literature strongly suggests that the institutional framework has a greater impact in shaping a country's economic development process in comparison to that of oil prices/revenues fluctuations, which is supported to a great extent by our findings. Hence, identifying key institutional factors and accounting for them in our analysis could be an interesting avenue for further research.

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Appendix

Data description and sources

Real oil revenues (*ror*): Following Gasmi and Laourari (2015), this variable is the nominal oil revenues adjusted for both exchange rate and imported inflation fluctuations. Data are expressed in constant US dollars (2005$).

Real GDP (*rgdp*): Data on real GDP were collected from the WB database. This variable is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Data are expressed in constant US dollars (2005$). It is included in our regression to account for the changes in Algeria's level of economic development.

Industrial growth (*indus*): Data on industrial growth were collected from the WB database. This variable aggregates the value added of the industries belonging to the International Standard Industrial Classification (ISIC) codes 15 through 37. The value added corresponds to the net output of a sector after adding up the value of all outputs and subtracting those of all the intermediate inputs. The origin of value added is determined by the ISIC revision 3. This variable is used as a proxy for the level of development of Algeria's industrial sector, hence for its level of industrialization.

Oil-macroeconomy nexus literature

Table A1- Recent empirical literature on oil-macroeconomy nexus in oil-exporting countries

Study	Subject of investigation	Econometric approach	Finding
Moshiri, (2015)	The non-linear effects of oil price shock on macroeconomic performance in nine major oil-exporting countries, six developing and three developed countries. (oil price shocks, economic growth, investment, exchange rate, and inflation rate).	- VAR model and GARCH method. - Annual data, 1970-2010.	- Oil shocks have asymmetric effects in oil-exporting developing countries and do not have significant effect on economic growth in oil-exporting developed countries. Heterogeneous responses to oil price shocks in these countries can be explained by differences in their institutional quality.
Alley *et al.,* (2014)	The impact of oil price shocks on the Nigerian economy (GDP, aggregate consumption, aggregate investment, government expenditure, imports, and exports).	- GMM. - Annual data, 1981 - 2012.	- No significant impact of oil price shocks on economic growth. However, shocks create uncertainty and undermine the management of oil revenues. - Significant positive impact of oil prices on economic growth.
Bouchaour and Al-Zeaud, (2012)	The effect of oil price volatility on Algerian economy (Real oil price, real GDP, unemployment, inflation rate, real effective exchange rate, money supply).	- VECM and VD analysis. - Annual data, 1980 - 2011.	- Oil prices changes have a very limited impact on most macroeconomic variables in short run. In the long run, they have positively affected real GDP and inflation and have a negative impact on unemployment and real effective exchange rate.
Iwayemi and Fowowe, (2011)	The effects of oil price shocks on Nigeria's economy (Real GDP, government expenditure, inflation, real exchange rate, and net exports).	- VAR, Granger-Causality tests, IRF and VD. - Quarterly data, 1985- 2007.	- Oil price shocks do not have a major impact on most macroeconomic variables in Nigeria. - Negative oil shocks significantly cause output and the real exchange rate.

Berument *et al.,* (2010)	Oil shocks effects in selected MENA countries (Analysis of oil price shocks on real exchange rate, inflation and output).	- VAR and IRF for 16 countries. - Annual data over the 1952-2004 period.	- Oil price increases have a statistically significant and positive effect on the outputs of Algeria, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Syria, and the United Arab Emirates.
Esfahani *et al.,* (2009)	Oil Exports and the Iranian Economy (Oil exports, real output, inflation, real money balances, and the real exchange rate).	- 5 variables, VARX and IRF. - Quarterly data, 1979-2006.	- A rather rapid response of the economy to shocks due to underdeveloped nature of the money and capital markets in Iran.
Jbir and Zouari-Ghorbel (2009)	Oil and the Tunisian economy (oil prices, government spending, inflation, real effective exchange rate and industrial production)	- 5 variables VAR, IRF, and VDC. - Quarterly data 1993-2007.	- No direct impact of oil price shocks on the economic activity. - Most significant channel by which the effects of the shock are transmitted is the government's spending.
Mehrara, (2008)	The asymmetric effects of positive and negative shocks of oil revenue changes on economic activities for 13 oil-exporting countries. (Investment, population growth, initial per capita GDP, and initial human capital, proxies for oil shocks).	- GMM - Annual data, 1965 - 2004.	- Output growth is adversely affected by the negative oil shocks, while oil booms or the positive oil shocks play a limited role in stimulating economic growth.

Figures

Figure A1- Inverse Roots of AR Characteristic Polynomial

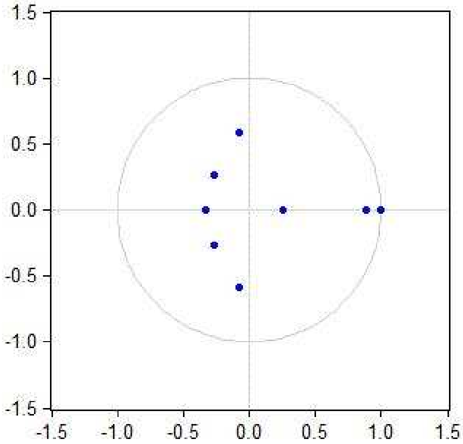

Figure A2- Generalized IRFs