OIL PRICES AND THE ALGERIAN EXCHANGE RATE: IS THERE ANY DIFFERENCE WITH HIDDEN CO-INTEGRATION?

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Abstract

Research background: The aim of this paper is to examine the long run relationship among oil prices and the Algerian Dinar exchange rate over the period January 1995–February 2020 in Algeria as one of the most important oil-exporting countries and one of the OPEC members.

Purpose: This study investigated the co-integration relationship between oil prices and exchange rate in Algeria by testing the long-run relationship between the two variables and their positive and negative shocks.

Research methodology: the study applied both the traditional co-integration analysis using Engle-Granger, Phillips-Ouliaris and Johansen-Juselius tests and the hidden co-integration presented by Granger and Yoon (2002).

Results: The results revealed that there is no evidence of a co-movement and linkage between oil prices and exchange rate in Algeria over the period of study neither with the original series nor between the cumulative components whatever the dependent variable.

Novelty: This paper fills in the missing link between the Algerian Dinar exchange rate and oil prices especially with the absence of the hidden co-integration analysis in the case of Algeria and most of the developing countries. To deal with the oil shocks according to Apergis and Miller (2007) and Narayan and Gupta (2015) studies where when they suggested distinguishing between the negative and positive oil price shocks because the asymmetric effect on the macroeconomic variables.

Keywords: Exchange rate, Oil prices, Hidden co-integration, asymmetric relationships

Jel classification: C32, F31, Q43

Introduction

The exchange rate and its behavior has been a crucial topic in the last decades especially after the 2008 world financial crisis. The exchange rate is one of the most important tools to for having favorable international competitiveness, as Italy before the 2000's and China nowadays. Moreover, since the first two major oil prices shocks in 1973 and 1979, the relationship between oil prices and exchange rates started to be researched. Consequently, back to Krugman (1983) and Golub (1983), these two earlier studies were concluded that both oil exporting and oil importing countries may experience exchange rate appreciation or depreciation respectively when oil prices rise and depreciation (appreciation) when oil prices fall (Reboredo, 2012). This is what was confirmed by Bloomberg and Harris (1995) on the relationship between oil prices and the American Dollar exchange rate. For the oil exporting countries, it is clear that the fluctuations in TOT index (Terms of Trade index) influences directly and strongly by the fluctuations in oil prices, as in Algeria where the proportion of oil exports is more than 97% of total exports. In the same extreme, under the HLM effect (Harberger-Laursen-Metzler effect) and the PS effect (Prebisch Singer hypothesis). The (TOT) deterioration will cause a decrease in national savings and a deterioration of the current account balance, this will increase the real expenditure in order to maintain a standard of living; and thus will eventually lead to a decline in real income (Svensson, Razin, 1983). On the other hand, Mendoza (1995) suggested that the absence of investment and production decisions (as in Algeria with a very low degree of investments) produced unrealistic dynamics for net exports and real exchange rates. And at a global scale, Reboredo (2012) showed that large increases in oil prices like in the beginning of the new millennium have been considered for economic recessions, high inflation rates, trade deficits and low values of stocks and bonds for importing countries in contrast of oil exporting countries except the high inflation rates which means the presence of the Dutch disease in most of these countries. For this reason, we find several models that have been developed to deal with the determination of exchange rates like the interest rate parity, the monetary model, the PPP model (Purchasing Power Parity model) and the Taylor rule.

Algeria as one of the oil exporting countries produces an average of 1.3 million barrels per day, and with more than 60% of total government revenues, it's clear that oil prices are the most important factor and key factor to be considered in the consideration of economic policy. After the collapse of oil prices in 2014, the Algerian economy entered a real crises according to the large decline of its total income from 60 billion dollars in 2015 to 27.5 billion in 2016, and this is what eroded the foreign exchange reserves with a fall from 193 billion dollars in 2013 to

105 billion in 2017 and then to 50 billion in 2019. As a response to this collapse, the Algerian government pursued an austerity policy in 2016 by reducing its expenditures and increasing its taxes in addition to stopping many investments and projects which has led to an increase in the unemployment and poverty rates (from 9.5 to 12% for unemployment and from 9 to 11% for poverty between 2014 and 2018 respectively). This problem continued with the beginning of the year 2020 as the COVID-19 disease that struck China at the end of 2019 spread to all countries around the world, this is as a consequence reduced the global demand for oil when prices fell to 22 dollars in mid-March.

The present study aims to contribute to the literature by examining the relationship between crude oil prices and the Algerian Dinar exchange rate using monthly data covering the period from January 1995 to February 2020 for the first time. In doing so, the paper uses the new concept of co-integration presented by Granger and Yoon (2002) named the hidden co-integration to get the global idea about the long run relationship between the two variables. Therefore, we use at first the traditional co-integration tests depending on Johansen-Juselius (1992) test, the Engel-Granger (1987) test and the Phillips-Ouliaris (1990) test, then the hidden co-integration test under the Granger and Yoon procedure after the making of the negative and positive cumulative components of the two series.

This paper is organized as follows, section one is the introduction where the problems are raised and the objectives are clarified, section two throws light at the relevant literature, section three describes the data set and explains the econometric tests, section four presents the empirical results and section five concludes the paper with policy recommendations.

1. Oil production in Algeria

According to the Rystad Energy UCube 2016 database. The cost of producing a barrel of oil in Algeria was 20.2 dollars per barrel (7.2 dollars as production costs and 13.2 dollars as capital spending) in the 14th rank around the world, where the first rank was for Saudi Arabia by 8.98 dollars per barrel (3 dollars as production costs and 5.98 dollars as capital spending). In addition to this, and according to the Algerian budget, the reference price of oil was estimated at 45 dollars per barrel in 2020 after the 37 dollars price since 2015. All of these new facts put the Algerian economy in a real dilemma especially because of the uni-economic sector (hydrocarbon sector) and the total absence of real industrial and agricultural sectors. As we mentioned, Algeria is strongly dependent on oil and gas exports by more than 97% of total exports, and more than 30% of the Gross Domestic Product (GDP), and back to the history

of the Algerian economy, it's so clear that rising oil prices (like the 1973 and 1979 oil shocks, the high prices from 2002 to 2008 and then from 2010 to 2014) were the key determinant in any economic activity as the five-year plans adopted by the government at the beginning of the new millennium as a response to the rise in world oil prices (525 billion Dinars for the first plan 2000–2004; 4202 billion Dinars for the second 2005–2009 and 286 billion Dollars for the 2010–2014 plan). Figure 1 shows all these changes in oil prices and the GDP changes for the same period of 1970–2018 depending on the World Bank 2019 database. Hence, the figure shows that the GDP changes are the same with the oil changes especially the prices in 2007, 2009 and 2014 due to the high prices in 2007, 2008 collapse and the deterioration of oil prices in 2014.

Figure 1. Changes in oil prices and Algerian GDP over the period 1970–2018

Source: own elaboration according to World Bank database 2019.

Algeria as many developing countries, is one of the oil exporter countries, in this area Algeria is the leading natural gas producer in Africa, the second largest natural gas supplier to Europe and one of the top three oil producers in Africa. In 2016, Algeria exported 32 billion dollars and imported 48.6 billion dollars with a negative trade balance of 17.3 billion dollars according to the decline in oil prices in the international market. To get a clear idea about the exports commodities of Algeria in 2016, it is important to know that the top exports were petroleum gas at 13.1 billion, crude petroleum at 10.3 billion, refined petroleum at 5.6 billion, nitrogenous fertilizers at 444 million and Ammonia at 417 million dollars. For this reason the Algerian economy is heavily exposed to shocks and deteriorations of terms of trade especially with the prices of crude oil and gas. Figure 2 shows the evolution of production and consumption of both oil and gas in Algeria for the period 2005–2015.

Figure 2. The evolution of oil and gas consumption and production

Source: Cedigaz statistical database 2019.U.S Energy Information Administration database.

2. Literature review

Many researchers around the world established the connection between oil prices and exchange rates. Chaudhuri and Daniel (1998) based on Amano and Van Norden (1995) worked on the effect of oil prices on a country's TOT index, they declared that when the relative price of oil increases, the relative of the output bundle of all the commodities in an oil producing country should directly rise, in contrast to non-oil producing countries; this what will increase the real exchange rates through the channel of TOT index especially in the countries with a uni-sector economy like Algeria. Chaudhuri and Daniel (1998) suggested that the non-stationary of US Dollar real exchange rates over the post-Bretton Woods era is due to the non-stationary behavior of real oil prices. The same results were reached by Camarero and Tamarit (2002) with the Spanish Peseta when was the real oil price was one of the main determinants of the long run exchange rate. The same thing happened with the Norwegian exchange rate in Akram's (2004) study where he provided evidence that the exchange rate in Norway varied with the oil price level and trend using the VAR model. In China Huang and Guo (2007) suggested that oil prices shocks led directly to a minor appreciation in China's real exchange rate. Likewise Chen and Chen (2007) using the GARCH-M model (Generalized Auto-Regressive Conditional Heteroskedasticity in mean) for the G7 countries, found that real oil prices were a key determinant factor of real exchange rates movements with a significant forecasting power. And there are many other studies which confirmed that oil prices are a really significant and important key determinant in forecasting exchange rates and multiple macroeconomic variables.

In last two decades, the relationship between oil prices and macroeconomic variables has caused a hot debate among Algerian researchers. Jbir and Zouari (2011) depending on quarterly data covering the period 1995Q1–2007Q3; had tried to examine the relationship between oil prices and the Algerian Dinar exchange rate under the Dutch Disease, and they found that the increase in the inflation rate due to oil price shocks is the main cause of the real exchange rates appreciation in the short term according to the oil prices shocks. This study was repeated by Gasmi and Laourari (2017) for yearly data covering the period 1960–2013 using an ARDL model to test the co-integration relationship between real oil prices and the real effective exchange rate of the Algerian Dinar, to examine a robust long-run relationship among the two variables controlled by relevant variables (productivity differential; government expenditure; net foreign assets; terms of trade; share of the manufacturing sector in GDP; inflation rate; real GDP per capita and degree of openness). The main result of the study is that there is no evidence at the 5% significance level of a co-integration relationship among the variables which led them to reject the support of the spending effect as a symptom of the Dutch disease. Back to 2014, Benhabib et al (2014) examined the relationship between oil price and the nominal US Dollar/Algerian Dinar exchange rate using the VAR model depending on monthly data for the period 2003–2013. The results showed that there is no co-integration relationship between the two variables. On the other hand, the results of the VAR model in a short run term indicated that a 1% increase in oil price would tend to depreciate the Algeria Dinar against the US Dollar by 0.35%. This result emphasizes how the Algerian dinar is a non-oil currency. Smahi and Si-Kamel (2018) carried out a study to examine the relationship between oil price and nominal US Dollar/Algerian Dinar exchange rate using the VECM model upon monthly data for the period 2008–2015. The results showed that a co-integration relationship was detected between the two variables with a bilateral causality in both short run and long run terms. Furthermore, the results indicated that a change in oil price would tend to depreciate the Algerian Dinar against the US Dollar. Djebbouri (2018) investigated the impact of oil price shocks on the exchange rate of the Algerian economy using the VECM model over the period 1980–2017 with annual data. The findings concluded that the shocks in the world prices of crude oil play an important role in explaining the movements of the Algerian exchange rate with a negative manner. The last study in Algeria is the Boussahaal (2018) study which made a contribution by using the Periodic Multivariate Auto-Regressive Stochastic Volatility model (PVAR-SV model) to detect the Granger causality in volatility in order to capture periodicity in stochastic conditional variance. The paper used daily data covering the period 3 January 2005 to 31 December 2015 with 2,836 observations for each series of Saharan Blend oil spot price, Euro/US Dollar exchange rate,

Euro/Algerian Dinar exchange rate and US Dollar/Algerian Dinar exchange rate. The results revealed that oil prices had a good volatility forecasting performance for the three exchange rates in the model.

On the other extreme, Rickne (2009) examined the co-movement between oil prices and real exchange rates in 33 oil-exporting countries using panel data over the period 1985–2005. The study focused on the role of institutions (Bureaucratic quality, corruption, democratic accountability, investment profile, ..., etc). The results confirmed the co-movement of oil prices and the exchange rates among the sample. In addition to this, the countries with high bureaucratic quality, string and impartial legal systems have real exchange rates that co-move less with oil prices. Nikbakht (2009) studied the relationship between oil prices and exchange rate in OPEC members (Algeria, Indonesia, Iran, Kuwait, Nigeria, Saudi Arabia and Venezuela) over the period 2000M01–2007M12 with monthly data. The results showed that there is a long run linkage between the two variables. Al-mulali and Che Normee (2012) investigated the impact of oil price shocks on the real exchange rate over the period 2000–2010 in 12 oil-exporting countries (Algeria, Bahrain, Egypt, Indonesia, Kuwait, Nigeria, Oman, Saudi Arabia, Sudan, the United Arab Emirates and Venezuela) according to panel data. The study used six variables namely real exchange rate national currency per US Dollar as dependent variables with oil price, inflation rate, government consumption expenditure, GDP and the current account balance, as independent variables. The main result from the study was that any increase in oil prices caused a real exchange rate appreciation in all of these countries. Mohammadi and Jahan-Parvar (2012) studied the long run relation and short run dynamics between real oil prices and real exchange rates in a sample of 13 oil-exporting countries (Colombia, Gabon, Indonesia, Mexico, Nigeria Norway, Venezuela, Algeria, Angola, Bolivia, Kuwait, Russia and Saudi Arabia). The authors used the Threshold and Momentum Threshold Auto-Regressive models (TAR and M-TAR) to examine the existence of the Dutch Disease. The results revealed the existence of a co-integration relationship only in Bolivia, Mexico and Norway with a long run effect running from oil prices to exchange rates with no causal relationship between them in the short run term. In over all, the findings suggested a weak relationship between the two variables. The final study in this brief literature about Algeria in the linkage between oil price and exchange rate is the Bala and Chin (2018) study. This paper investigated the asymmetric impacts of oil price changes on inflation rate in Algeria, Angola, Libya and Nigeria, the paper used three different oil prices; the actual spot oil price of individual countries, the OPEC reference basket oil price and the average of the Brent, WTI and Dubai oil price using the dynamic panel ARDL. Where the results indicated that the impact is more significant when oil prices dropped.

As shown by the number of studies reviewed, most of the studies concluded that there is no co-integration relationship in Algeria and oil-exporting countries because of the absence of the co-movement between oil prices and exchange rates. However, these findings do not mean the full absence of a co-integration relationship, and there is an important probability of the existence of hidden co-integration of long run linkage between the cumulative components of the two variables. For this reason, this paper aims to contribute to the existing literature by studying the hidden co-integration between oil prices and the Algerian Dinar exchange rate over the period 1995M01–2020M02 to get a clear idea about the co-movement of the two variables in the long run term under the Granger-Yoon (2002) co-integration procedure.

3. Methodology

The term co-integration is one of the most important concepts in econometrics if not the most important, almost thirty years have passed since the introduction of the co-integration problem by Granger (1981, 1983) and Engle and Granger (1987) with the new concept of the Error Correction Model (ECM) to deal with the non-stationary and integrated series, and there are many other papers and procedures to test the co-integration relationship as Granger and Swanson (1996); Enders and Siklos (2001); Park and Granger (2001); threshold co-integration proposed by Balke and Fomby (1997); co-integration with structural breaks as Gregory Hansen (1996), Hatemi-J (2014) and Maki (2012) and many others (Granger, Yoon, 2002), the concept of co-integration in general occurs when the economic data respond to the same shocks together and they are not co-integrated if they respond separately to the same shocks, but as stated by Granger and Yoon (2002) what would happen if they respond together only to certain kinds of shocks (positive or negative)? This is what is meant by the asymmetric response in the time series that is named as the hidden co-integration in the earlier literature. Back to our subject and study, it's important to know that the positive shocks and negative ones are not the same in both oil prices and exchange rates and the relationship between them; and this is what has been confirmed by many studies such as Coleman et al. (2010); Ahmed and Hernandez (2013); Akram (2004); Buetzeret et al. (2012) and Kilian (2009) where they divided oil prices in different components based on demand and supply changes and shocks using the Threshold Autoregressive models (TAR; STAR and MTAR models) (Panagiotis and Constantinos, 2016).

Economic series are co-integrated if and only if they respond to the same shocks together for a long time, and they are not if they respond separately to the same shocks for a long time (Granger, Yoon, 2002). The first appearance of the term co-integration was in 1981 and 1983 by

Granger to test for the long run equilibrium between economic variables as in Engle-Granger (1987) on the stock market indices equilibrium. The basic idea of co-integration is that series Y_{1t} and Y_{2t} for example should move together without deviating one from another in the long run term (Alexakis et al. 2016). And the most important condition is that should the series be integrated in the same order but not $I(0)$ and the gap between these variables should be integrated in a smaller order than the order of the integration of the series:

$$Y_{1t}, Y_{2t} \sim I(d) \quad (1)$$

$$\varepsilon_t = Y_{1t} - aY_{2t} \quad (2)$$

$$\varepsilon_t \sim I(d-b) \quad (3)$$

where ε_t is the white noise for the equation, and d is the order of integration and b should be $0 < b < d$, and a is the co-integrated parameter.

However, Granger and Yoon (2002) asked “what would happen if these non-stationary series respond together only to a certain kind of shocks ‘positive or negative)? And this was really confirmed by Apergis and Miller (2009) and Narayan and Gupta (2015) in the changes in oil prices for both exporting and importing countries, for this reason, the co-integration relationship among positive and negative shocks for economic variables (oil prices for example) caused a hot debate between the researchers in the name of hidden co-integration.

Assuming that we are trying to test the co-integration relationship between two integrated variables Y and X defined as the following random walk processes:

$$y_t = y_{t-1} + \varepsilon_{1t} = y_0 + \sum_{i=1}^t \varepsilon_{1i} \quad (4)$$

$$x_t = x_{t-1} + \varepsilon_{2t} = x_0 + \sum_{i=1}^t \varepsilon_{2i} \quad (5)$$

where y_0 and x_0 are the initial values, and the variables ε_{1t} and ε_{2t} signify white noise disturbance terms, and the cumulative positive and negative components (shocks) are defined as $\varepsilon_{1t}^+ = \max(\varepsilon_{1t}, 0)$ and $\varepsilon_{2t}^+ = \max(\varepsilon_{2t}, 0)$ for positives shocks or $\varepsilon_{1t}^- = \min(\varepsilon_{1t}, 0)$ and $\varepsilon_{2t}^- = \min(\varepsilon_{2t}, 0)$ for negative shocks, therefore $\varepsilon_{1t} = \varepsilon_{1t}^+ + \varepsilon_{1t}^-$ and $\varepsilon_{2t} = \varepsilon_{2t}^+ + \varepsilon_{2t}^-$, and as a result the random walk processes will be as follows (Hatemi-J, 2019):

$$y_t = y_{t-1} + \varepsilon_{1t} = y_0 + \sum_{i=1}^t \varepsilon_{1i}^+ + \sum_{i=1}^t \varepsilon_{1i}^- \quad (6)$$

$$x_t = x_{t-1} + \varepsilon_{2t} = x_0 + \sum_{i=1}^t \varepsilon_{2i}^+ + \sum_{i=1}^t \varepsilon_{2i}^- \quad (7)$$

Moreover, we can write the positive and negative shocks of each variable as $y_t^+ = \sum_{i=1}^t \varepsilon_{1i}^+$ and $y_t^- = \sum_{i=1}^t \varepsilon_{1i}^-$ for Y variable and $x_t^+ = \sum_{i=1}^t \varepsilon_{2i}^+$ and $x_t^- = \sum_{i=1}^t \varepsilon_{2i}^-$ for X variable, and then the process is ready to test the co-integration relationship between these components under the Engel-Granger (1987) procedure or any other test of co-integration tests.

4. Results

We use in this paper monthly data covering the period January 1995 to February 2020 (302 observations) for the crude oil prices (OIL) and real effective exchange rate for the Algerian Dinar (EXC), both of the series are obtained from the Federal Reserve economic database, the first analysis for the series is both the curve of the original series and the first differences series to get a clear idea about the behavior of the two variables, Figure 1 shows different periods of appreciation and depreciation in the two series, and the main observation is that we cannot say that there is the same behavior between oil prices and exchange rate in Algeria especially for the period January 1995 to mid 2004 because of the high levels of oil prices from 2004 to 2012.

Figure 3. The evolution of oil prices and the Algerian exchange rate 1995–2020

Source: own elaboration according to Federal Reserve economic database 2020.

Figure 4. The evolution of oil prices and the Algerian exchange rate in differences

Source: own elaboration according to Federal Reserve economic database 2020.

4.1. Unit root test

As usual, the first step in time series analysis is the unit root test to examine the stationarity of the series and to get the order of integration to determine the optimal econometric procedures to deal with the variables under examination, for this reason, we use both the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests. The results from Table 1 show that both of the two series are not stationary at their levels and they get stationary with the first differences which makes them $I(1)$. On the other hand, Table 2 shows the BDS (Brock, Dechert and Scheinkman) test to examine the non-linear behavior of the series, and the results obtained from the test suggest that both of the series have a linear behavior among the period of study.

Table 1. The unit root tests results

Variables	ADF		PP	
	Statistic	Probability	Statistic	Probability
OIL	-2.555	0.301	-1.583	0.797
EXC	-3.047	0.121	-2.921	0.157
D(OIL)	-11.665	0.000***	-11.394	0.000***
D(EXC)	-14.262	0.000***	-14.102	0.000***

D: denotes the first differences; *** denotes the significance at 1, 5 and 10% significance levels.

Source: own elaboration using the Eviews program.

Table 2. BDS test results

Dimensions	BDS stat	Std.Error	Z_statistic	Normal Prob	Bootstrap prob
OIL					
2	0.17960	0.002958	60.7148	0.0000	0.0000
3	0.30263	0.00467	64.6860	0.0000	0.0000
4	0.38378	0.005542	69.2548	0.0000	0.0000
5	0.43573	0.005744	75.8604	0.0000	0.0000
6	0.46692	0.005508	84.7750	0.0000	0.0000
EXC					
2	0.18637	0.003875	48.09830	0.0000	0.0000
3	0.31550	0.006150	51.30070	0.0000	0.0000
4	0.40287	0.007312	55.09862	0.0000	0.0000
5	0.46142	0.007608	60.64892	0.0000	0.0000
6	0.49950	0.007324	68.20241	0.0000	0.0000

Source: own elaboration using the Eviews program.

4.2. Co-integration tests

After determining the two variables they are I(1) series, we shall continue with the co-integration analysis to detect the long run relationship between the two variables with three different tests (Engle-Granger test, Phillips Ouliaris test and the Johansen Juselius test). It's clear from Table 3 that we cannot reject the null hypothesis of no co-integration relationship in all the three tests, this is what is confirmed in the results from Figure 1 above, subsequently, there is no long run relationship between the oil prices and the Algerian exchange rates over the period January 1995–February 2020.

Table 3. Co-integration tests results

Engel Granger test				
dependent variable	tau-statistic	probability	z-statistic	probability
EXC	−2.611	0.235	−16.319	0.111
OIL	−3.047	0.102	−19.354	0.059
Phillips Ouliaris test				
dependent variable	tau-statistic	probability	z-statistic	probability
EXC	−2.569	0.252	−13.202	0.203
OIL	−2.727	0.193	−15.250	0.137
Johansen Juselius test				
null hypothesis	eigenvalue	trace statistic	critical value	probability
$r = 0$	0.0299	11.201	15.494	0.199
$r \geq 1$	0.0073	2.183	3.841	0.139

Source: own elaboration using the Eviews program.

4.3. Hidden co-integration tests

From the co-integration results, we conclude that the two variables do not respond to shocks together and they respond separately to shocks, but this result does not mean the full absence of the co-integration relationship because the probability of the existence of a hidden co-integration relationship exists if they respond together only to certain kinds of shocks (positive or negative). The next step in our study after the getting the cumulative components of the series is to examine the existence of a hidden co-integration relationship among the original variables series and the cumulative components series. Before applying the co-integration tests we should before determine the order of integration to the cumulative components series using the ADF and PP tests, and it's clear that all of the series are I(1) series.

Table 4. The unit root tests the results for the cumulative components series

Variables	ADF		PP	
	statistic	probability	statistic	probability
EXC ⁺	-0.367	0.988	-1.093	0.927
EXC ⁻	-0.265	0.991	-0.773	0.965
OIL ⁺	-2.841	0.183	-2.609	0.276
OIL ⁻	-1.926	0.638	-1.907	0.648
D(EXC ⁺)	-5.265	0.000***	40.055	0.000***
D(EXC ⁻)	-5.319	0.000***	-40.120	0.000***
D(OIL ⁺)	-14.839	0.000***	-15.086	0.000***
D(OIL ⁻)	-10.146	0.000***	-10.176	0.000***

D: denotes the first differences; *** denotes the significance at 1, 5 and 10% significance levels.

Source: own elaboration using the Eviews program.

Since the six series are I(1) series we can apply the co-integration tests to examine the long run relationship between the original variables (OIL and EXC) with the shocks series (EXC⁺ and EXC⁻ are the positive and negative shocks of exchange rate respectively and OIL⁺ and OIL⁻ are the positive and negative shocks of oil prices respectively) two by two as shown in Table 5.

Table 5. Granger-Yoon co-integration tests results

Dependent variable	Independent variable	With trend	Without trend
1	2	3	4
OIL	EXC ⁺	-2.96 (2)	-2.95 (2)
OIL	EXC ⁻	-2.95 (2)	-2.93 (2)
EXC	OIL ⁺	-1.69 (19)	-1.71 (19)
EXC	OIL ⁻	-1.55 (19)	-1.61 (19)
OIL ⁺	EXC ⁺	-2.25 (10)	-1.48 (12)
EXC ⁺	OIL ⁺	-2.23 (10)	-1.89 (12)

1	2	3	4
OIL-	EXC+	-1.58 (10)	-1.18 (10)
EXC+	OIL-	-1.55 (10)	-1.83 (10)
OIL-	EXC-	-1.63 (5)	-1.22 (6)
EXC-	OIL-	-1.60 (5)	-1.97 (6)
Critical values at 5% significance level		-3.42	-2.87

The numbers within the brackets indicate the number of lags, which are determined based on the Akaike criterion.

Source: own elaboration using the Eviews program.

As stated by Apergis and Miller (2007), changes in oil prices do not have uniform effects on all the macroeconomics variables. For this reason, researchers should distinguish the aggregate oil price shocks into positive and negative shocks to eliminate the significant deficiencies of previous studies. According to the Granger-Yoon (2002) test under the Engel-Granger (1987) procedure table 5 shows that we cannot reject any null hypotheses of a no co-integration relationship among all the cases since all the statistics both for the trend model and without the trend model are smaller than the critical values at a 5% significance level. This means that there is an absence of hidden co-integration between oil prices and the Algerian real effective exchange rate over the period January 1995–February 2020. Therefore, oil prices are not a good variable to be used by investors to make decisions about the exchange rates in Algeria because of the full absence of co-integration relationships.

Conclusions

The aim of this paper was to find out whether the Algerian Dinar real effective exchange rate moved together with oil prices during the period January 1995–February 2020. To achieve this, the co-integration test for the long run relationship was used both with an original data series and with the cumulative components for both of the two variables to deal with the asymmetric relations. Depending on Apergis and Miller (2007) and Narayan and Gupta's (2015) studies; we can distinguish between the positive and negative shocks in order to run the Granger-Yoon (2002) test for hidden co-integration. Based on the findings, the main result is the full absence of the long run relationship between world oil prices and real effective exchange rate in Algeria over the period of study by 302 observations for each variable; this can be explained because the Algerian Dinar is not an oil currency like the US Dollar. On the other hand, the absence of this co-movement in the context of Algeria is due to many factors. At first, according to Djedaïet and Ayad's (2017) study about the sterilization policy in Algeria they found that the sterilization coefficient was equal to -0.99 in the period between January 2002 and December 2016. This

result means that the full sterilization by 99% of the frequent hard currency inflows in both short run and long run terms coming from hydrocarbures exports with more than 97% of oil rents makes the Algerian economy isolated from the international oil shocks. In addition, the reference price for oil in the government budget was 19, 29, 37 and 50 over the period of study, for this reason any changes in oil prices above these reference prices cannot effect the Algerian economy, especially in the short run term; and as we can see in the graphs the oil prices over the period of the study remained above the reference prices. These two factors can be a big explanation for the absence of the co-movement between oil prices and Algerian exchange rate, on the other hand.

Finally, the study has shown that the co-movement between oil prices and exchange rate in Algeria cannot be acceptable at the 5% significance level neither with a traditional co-integration relationship using the original series nor the hidden co-integration relationship using the cumulative components. According to the results, it is recommended that the Algerian government should diversify its exports basket to avoid future oil price shocks especially in the wake of the deterioration of the prices in March 2020 according to the SARS-COV-2 (COVID-19 disease) virus below the 20 Dollars per barrel price. Thus, the Algerian Terms of Trade index is relative totally to the oil prices and this is what can cause many problems in the government budget in the long run term, which makes the diversification of the exports and the global economy an imperative necessity for the next few years.

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