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Estimating the equilibrium real exchange rate for Algeria.

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Abstract:

The purpose of this study is to investigate the long run path of equilibrium real exchange rate in Algeria as a response to some fundamental variables, which are; productivity differentials relative to trading partners, real prices of oil and government spending. A data sample of annual frequency running from 1980 to 2018 is used to analyze this relationship via JOHANSEN cointegration technique. Although all variables were significant in this study, Algeria's real exchange rate was found to be mostly driven by productivity differentials relative to trading partners and government spending, Furthermore, the study also found that equilibrium real exchange rate is not constant as would be implied by theory, but, rather it is time varying process that depends strongly on the chosen fundamental variables.

Keywords: *Keyword,* **:** *equilibrium real exchange rate,: fundamental variables,: JOHANSEN cointegration*

Jel Classification Codes: *C32, E59, F31.*

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1. INTRODUCTION

Algerian economy has long been dominated by hydrocarbon sector, which accounts for high percentage of fiscal budget, exports revenues and GDP, this dependence makes the economy fragile and very susceptible to external shocks. Diversification of the economy would alleviate the impact of external shocks and it require forecasting the exchange rate, which is in large part depends for commodity exporting countries like Algeria on oil price and some fundamental variables such as hydrocarbon production, government spending, trade barriers (Sorsa, P., 1999, P.4)

The exchange rate in Algeria have seen many regimes across time, in 1974 the exchange rate in Algeria was begged to a basket of currencies in which the US dollar was given a greater importance in comparison to other currencies considering the importance of US dollar in revenues receipts. Due to this scheme of begging any appreciation of US dollar would stimulate imports and reduce competitiveness of good exported (Koranchelian, T., 2005, PP.4-5).

From 1986 to end 1993 the exchange rate have seen many successive periods of devaluation exacerbated by oil shocks and diminishing exports revenuers. In period 1986 to 1988 the exchange was depreciated by 31%, between 1989 to 1991 the amount of depreciation has reached 200% in nominal terms, during 1991 to 1994 the nominal depreciation has averaged 4% on annual basis. During those successive periods of devaluation, the exchange was not in line with economic fundamentals and the gap between official and informal exchange rate has widen excessively driven by upward demand pressure. The Algerian government has taken many reforms such as expansionary fiscal and monetary policies to counteract the negative effects of currency depreciation, Because of these reforms; Algeria's inflation was consistently higher than that of its main trading partners (Koranchelian, T., 2005, PP.4-5).

In 1994, the Algerian authorities adopted a new regime of exchange rate determination with the support of international monetary fund as a step forward to determine exchange rate through supply and demand forces. The bank of Algeria had in fact established a daily fixing sessions with commercial banks, in practice, however, this new type of exchange rate control was not successful because it had the bank of Algeria as the only supplier of foreign currency (Chekouri, S. M et al., 2022, P. 06).

In 1996, Algerian authorities replaced the daily session with commercial banks with an interbank foreign exchange market. The bank of Algeria intervened in this market to adjust and monitor the path of real exchange rate and make consistent with the state of monetary policy, inflation rate, export revenues and some other fundamental variables (Touitou, M et al., 2019, P. 324).

The PPP in its absolute form states that the equilibrium real exchange rate is determined by relative price levels between the two countries when price levels are expressed in a common currency. the relative form of PPP claims that percentage change in exchange rate will adjust in response to inflation differential between the two countries, PPP does not hold perfectly because it depends on several assumptions that are not likely to hold in the real world (Tashu, M., 2015, P.4).

PPP predicts that deviations from equilibrium real exchange rate will die out in the long run and therefore the exchange will exhibit mean reverting property of stationary time series. In practice, however, real exchange rate dictated by the theory is not stable but behaves like time varying process, which led to the hypothesis that is, could be determined by a set of fundamental variables such as: term of trade, relative productivity of tradable to non-tradable goods, government consumption and foreign net assets (Tashu, M., 2015, PP.4-5).

2. Overview of the literature

Cashin, P et al (2003) in their article entitled "**common currencies and the real exchange rate**" investigated whether the real exchange rate moves in line with commodity exports. The researchers have constructed monthly price indices for national commodity export prices for 58 country over the period 1980-2002. The study found evidence in a favor of a long run relationship between real exchange rate and real commodity prices for about the third of countries tested. In contrast to purchasing power parity, which states the real exchange rate is stable, the study found that it is in fact a time varying process.

Koranchelian, T in his article entitled **" the equilibrium real exchange rate in a commodity exporting country: Algeria's experience**" has modelled and estimated the equilibrium real exchange rate path using a data sample covering the period 1990-2003. He found that Balassa-Sameulson together with the real price of oil have significantly explained the long run behavior of real exchange rate, furthermore, he has demonstrated that the real exchange was not stable ass assumed by purchasing power parity theory, but instead was a time varying process.

Sorsa, P (1999) investigated the long run relationship between real price of oil, hydrocarbon production, government spending, level of protection and real exchange rate using annual data running from 1980 to 1997, the paper showed that reduction of trade protection could depreciate the real exchange rate which in turn would improve competitiveness and diversification of the economy.

Ben-Naser, A et al (2018) investigated the long run relationship between real exchange rate and its fundamentals, which are; real oil prices, real relative productivity, openness and real growth rate. The study found that real oil prices and real relative productivity have a significant impact on real exchange rate; the misalignment has on the other hand estimated to be more than 40%, which might affect negatively the Libyan economy.

MacDonald, R., & Ricci, L. A (2003) investigated the long run relationship via johansen cointegration between real exchange rate and some fundamentals, namely, real interest rate differentials, GDP per capita relative to trading partners, real commodity prices, trade openness, fiscal balance and net foreign assets. The study showed that the real exchange rate has significantly depreciated compared to equilibrium level and the half-life deviation from equilibrium was found to be approximately more than two years.

Ait yahia, S et al (2017) investigated the long run relationship and misalignment of real exchange rate in Algeria using a sample of annual data running from 1980-2015. The study found significant long run relationship between real exchange rate and its fundamentals which are; terms of trade, openness, productivity differentials relative to trading partners, real price of oil and government spending, the study also found alternative episodes of undervaluation and overvaluation along with other ones in which real exchange rate was sufficiently close to equilibrium level.

Benhabib, A et al (2014) investigated the short and long run causal relationship between the price of oil and nominal bivariate exchange rate of Algerian dinar with the US dollar, the study did not found a valid long run relationship, in the short run, however, the study found a significant impact of oil price on nominal exchange rate.

3. Data and mythology

To evaluate the balassa –semelueson effect, the total factor productivity should be compared between the tradable and non-tradable sector for each country, but this measure is not available for many countries given the scarcity of capital stock data required the estimate the production function. For this reason and several others, many studies have used GDP per capita relative to trading partners as a proxy for productivity; this measure is given by following formula (Couharde, C.et al., 2020, P.10):

$$GDPc_{it} = \frac{GDPc_{it}}{\prod_{j=1}^{n}(GDP)^{W_{ij,t}}} \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where: $GDPc_{it}$ is GDP per capita in constant PPP prices in us dollar of country i at time t, $W_{ij,t}$ is country i's trade based weight for all its trading partners, n denotes the number of partners.

Given the large share of oil in Algerian's economy, the fluctuations of oil prices in international market would affect negatively the plans of investment and spending between the traded and non-traded sector, which in turn could lead to depreciation or appreciation of real exchange rate through relative prices (Sorsa, P., 1999, P.07)

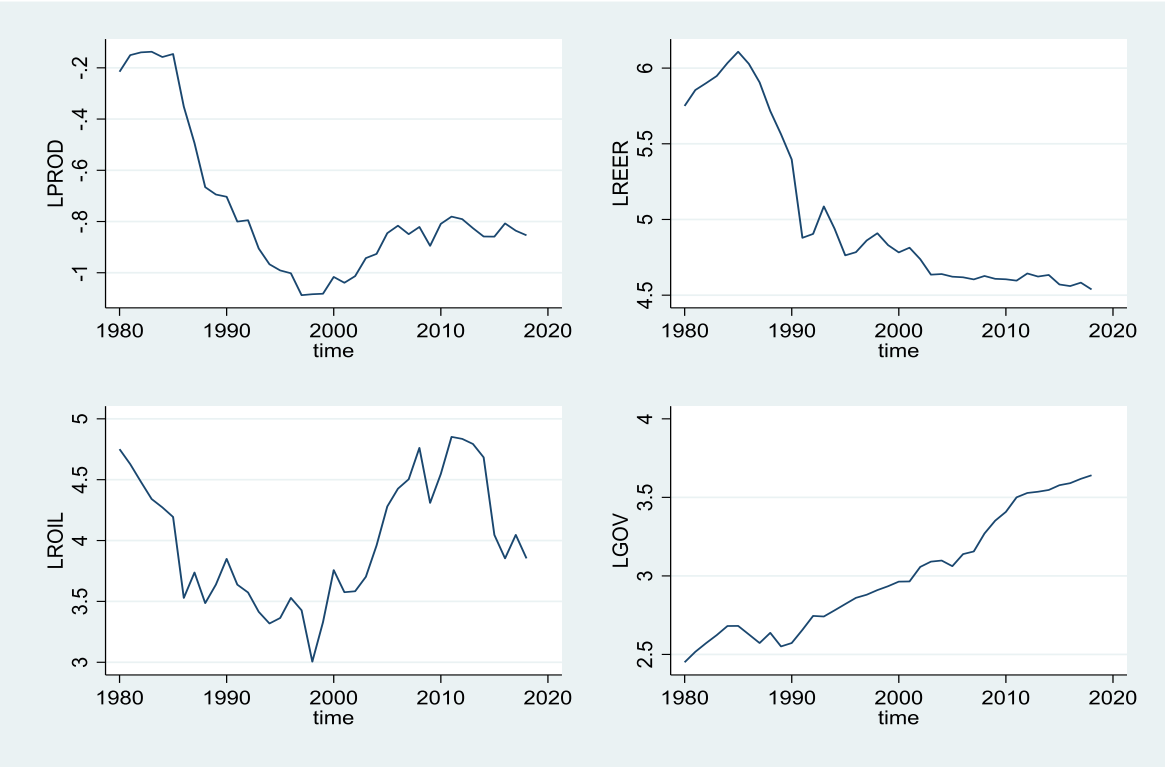
To measure the effect of oil prices on real exchange rate we have used the oil prices deflated by US consumer price as variable for real oil price. The source of data is the website of British petroleum company.

In most commodity exporting countries the government has a large share revenues, if the income elasticity of demand towards non-traded sector is greater than one, a rise in government consumption in non-traded sector would increase the prices and cause an appreciation in the equilibrium real exchange rate (Hossfeld, O., 2009, P. 07)

The real effective exchange rate is a measure of international competitiveness; it is geometric weighted average of the local currency against the currencies of the trading partners adjusted for inflation differential (Cashin, P., 2004, P. 244).

The source of data for real effective exchange rate is the IMF's international financial statistics where the base year is 2010. This variable is used in its log-form in this analysis.

Fig.1. Time evolution of the variables of the study



Source: Stata17. Output

In this study, the purchasing power parity is tested using augmented dickey fuller and Philips-Perron test assuming the following model:

$$\Delta LREER_t = a + bLREER_{t-1} + \sum_{t=i}^{p} \Delta LREER_{t-i} + \gamma t + e_t \dots \dots .2$$

Where; $lREER_t$ is the natural logarithm of real effective exchange rate, t is linear time trend, e_t is the residual term which assumed to be white noise.

To test the long run equilibrium exchange rate with the chosen fundamentals, we adopt the following model, which contain the short and long run interactions among the variables:

$$\triangle y_t = \alpha(\beta' y_{t-1} + u + \rho t) + \sum_{i=1}^{p-1} \Gamma_i \triangle y_{t-i} + \upsilon + u_t \dots \dots \dots .3$$

Where; $y_t = (LREER, \ LPROD, LROIL, LGOV)'$, is a vector containing; the log of real effective exchange rate, log productivity differentials, log real prices of oil, and log government spending respectively. α is the speed of adjustment matrix , β is a matrix that contain the parameters of long run relationship, u, ρ, v are constants to be estimated, u_t is vector of residuals which assumed to have multivariate normal distribution, Γ_i are matrices of short run parameters, the lag length p is chosen in order to achieve residuals normality.

4. Empirical finding and discussion

Before doing any meaningful estimation the data should be tested for stationarity, one of the main tests of unit root is augmented DICKEY FULLER test, which depends on estimating the following equations (Bhar, R., & Hamori, S, 2010, P. 47):

$$\triangle y_t = By_{t-1} + \sum_{i=1}^{p} \gamma_i y_{t-i} + u_t \dots\dots .4$$

$$\triangle y_t = u + By_{t-1} + \sum_{i=1}^{p} \gamma_i y_{t-i} + u_t \dots\dots 5$$

$$\triangle y_t = u + \varphi t + By_{t-1} + \sum_{i=1}^{p} \gamma_i y_{t-i} + u_t \dots\dots 6$$

The equations differ mainly in weather a constant or linear time trend is included as a deterministic term, the lag length is chosen to make the residual free of serial correlation. The critical values depends on the deterministic terms and the sample size, if the null hypothesis is rejected the time series will be stationary (Bhar, R., & Hamori, S, 2010, PP. 47-48)

Another alternative to augmented dickey fuller test is PHILIPS PERRON test, which is a non-parametric test, that is, it correct the presence of serial correlation by using NEWY-WEST heteroschedasticity and autocorrelation consistent covariance matrix, the formula for this test statistics is given by (Baum, C. F., & Hurn, S., 2021, P. 158):

$$t_p = t_B \left(\frac{\hat{\gamma}_0}{\hat{F}_0}\right)^{1/2} - \frac{T(\hat{F}_0 - \hat{\gamma}_0)Se(\hat{B})}{2\hat{F}_0^{\frac{1}{2}} * s} \dots\dots\dots 7$$

Where t_B is the augmented dickey fuller statistics, s is the standard error of the test regression, $\hat{F}_0$ is the long run variance and $\hat{\gamma}_0$ is the variance of the least square residuals. If the null hypothesis of unit root is rejected the process then will be stationary.

To test the presence of unit root test using augmented dickey fuller test. Model 6 which contain both non zero mean and time trend is used because the data series appear to be trending with a non-zero mean.

Table 1. Augmented dickey fuller test

Variables at level (model 6)			
	Test statistics	5% critical value	p-value
LPROD	-2.123	-3.556	**0.5334**
LREER	-1.203	-3.556	**0.9098**
LROIL	-2.278	-3.556	**0.4463**
LGOV	-2.349	-3.556	**0.4071**
Variables at first difference (model 6)			
LPROD	-3.235	-3.556	**0.0176**
LREER	-4.520	-3.556	**0.0014**
LROIL	-4.540	-3.556	**0.0013**
LGOV	-3.769	-3.556	**0.0182**

Source: Stata17. Output

As can be seen from table 1 the null hypothesis of unit root is not rejected at level but it is when the variables are expressed in first difference, therefore the data are integrated of order 1 and not stationary.

As we did with augmented dickey fuller test we have adopt a model with non-zero constant and time trend for Philips-Perron. The result for this test is displayed in figure 1.2.

Table 2. Philips-Perron test for unit root

Variables at level (model 3)			
	Test statistics	5% critical value	p-value
LPROD	-1.072	-3.548	**0.9336**
LREER	-1.440	-3.548	**0.8487**
LROIL	-2.281	-3.548	**0.444**
LGOV	-1.807	-3.548	**0.7015**
Variables at first difference (model 3)			
LPROD	-4.899	-3.552	**0.0003**
LREER	-4.496	-3.552	**0.0015**
LROIL	-5.704	-3.552	**0.0000**
LGOV	-5.352	-3.552	**0.0000**

Source: Stata17. Output

The results for PHILIPS-PERRON test reject a null hypothesis of unit root for all variables at level but cannot reject it at first difference; therefore, the data are integrated of order 1. The REER is proven to be non-stationary, which may suggest that purchasing power parity doesn't hold and the REER depends on fundamental variables.

4.1. Testing the long run relationship

Before running JOHANSEN cointegration test deterministic parts should be determined first, because VECM is modelled in first difference a constant implies a linear time trend in data at level whereas a linear time trend implies a quadratic trend in data at level (Hamrit, M., & hajab, A., 2021.P.109). The time series data appears to be fluctuating about either an upward or downward time trend, thus, we assume the following representation when testing for cointegration.

$$\triangle y_t = \alpha(\beta' y_{t-1} + u + \rho t) + \sum_{i=1}^{p-1} \Gamma_i \triangle y_{t-i} + v + u_t \dots\dots\dots 8$$

Where y_t is a vector, which contains the variables of interest, u, v are vectors of constants, Γ_i are matrices of short-term impact, α and β are matrices of speed of adjustment and cointegration coefficients respectively.

There are two variants of test available to determine the number of cointegration equations: the maximum eigenvalue and trace statistics. There are no major differences between them, in small samples however, the trace statistics power performance is superior to that of maximum eigenvalue (Lütkepohl, H et al., 2001, P. 305), because the sample data is not large enough, the trace statistics is chosen and the results are displayed in table 3.

Table 3. Johansen cointergration rank

Maximum rank	Params	LL	Eigenvalue	Trace statistic	Critical value 5%
0	36	157.59931	.	65.9751	62.99
1	44	170.94332	0.53351	39.2871*	42.44
2	50	182.97997	0.49732	15.2138	25.32
3	54	187.37625	0.22215	6.4212	12.25
4	56	190.58687	0.16762		

Source: Stata17. Output

As can be seen from table 3 the null hypothesis of no cointegration equation is rejected but the null hypothesis of one or fewer is not. Therefore, we proceed the estimation of vector autoregregressive model with one cointegration equation.

4.2. Testing the coefficients of the long run relationship

Having determined the existence of one cointegration equation, the table 4 shows the result of VECM model estimation assuming that the cointegration equation is trend stationary.

Table 4. The long run cointegration equation

beta	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
_ce1						
LREER	1	.	.	.	.	.
LPROD	-1.84805	.7079966	-2.61	0.009	-3.235698	-.4604025
LROIL	.8338194	.2837035	2.94	0.003	.2777708	1.389868
LGOV	-5.031797	1.214527	-4.14	0.000	-7.412226	-2.651368
_trend	.1653583	.0481925	3.43	0.001	.0709027	.259814
_cons	2.402636	.	.	.	.	.

Source: Stata17. Output

The result of table 4 shows that all the variables are highly significant. In this estimation, we adopt the JOHANSEN identification scheme by placing a coefficient 1 on the variable of interest LREER. The result can be written as:

$$LREE_{t-1} - 1.84LPROD_{t-1} + 0.83LROIL_{t-1} - 5.03LGOV_{t-1} + 1.16t + 2.40 \sim I(0) \ldots\ldots\ldots 9$$

The equation shows that all variables contribute significantly to equilibrium but it seems out that productivity differential and government consumption are the most effective variables as their magnitude is higher as opposed to other variables.

4.3. Testing coefficients about speed of adjustment

The speed of adjustment towards equilibrium gives information about how the dependent variables in a given equation respond to disequilibrium happened in last period, one of these coefficients should be a least significant otherwise the system reveals no valid cointegration, theses coefficients also should have opposite signs to be able to restore equilibrium (Box-Steffensmeier, J. M., 2014, P. 163). The estimated speed of adjustment matrix is shown in table 5.

Table 5. Speed of adjustment matrix

alpha	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
D_LREER						
_ce1						
L1.	-.1035641	.0603657	-1.72	0.086	-.2218787	.0147506
D_LPROD						
_ce1						
L1.	.0875552	.0387524	2.26	0.024	.0116019	.1635085
D_LROIL						
_ce1						
L1.	.2515624	.1811739	1.39	0.165	-.1035319	.6066567
D_LGOV						
_ce1						
L1.	.0968237	.0250703	3.86	0.000	.0476869	.1459606

Source: Stata17. Output

The coefficients of productivity differential and government spending although small in magnitude respond significantly to restore equilibrium by 8.7 % and 9.6% over a year respectively, real price of oil shows a high speed of adjustment but it is not significant in restoring equilibrium.

4.4. Model diagnostics

After estimating the parameters of the model, the next step is to check the model adequacy via testing the residuals, which have to be distributed normally with no serial correlation. The log likelihood function of the vector error correction model is derived assuming that the residuals follow a normal distribution (Johansen, S., 1995, P.141). The result for normality test is displayed in table 6.

Table 6. Jarque-Bera test for residuals normality

Jarque-Bera test

Equation	chi2	df	Prob > chi2
D_LREER	3.497	2	0.17406
D_DLPROD	3.328	2	0.18942
D_LROIL	2.021	2	0.36395
D_LGOV	2.634	2	0.26794
ALL	11.480	8	0.17597

Source: Stata17. Output

As can be seen from table 6 above, the null hypothesis of residuals normality for each equation and for all equations jointly is not rejected, therefore the residuals of the estimated model come from a normal distribution with a 5% significance level.

To test for residual autocorrelation we use the Lagrange multiplier test, which is a general test that allows for non-stochastic repressors and higher order for residuals autocorrelation and moving averages of white noise terms (Gujarati, D. N., & Porter, D. C., 2009, P. 438). The result of this test is displayed in table 7 below.

Table 7. Lagrange multiplier test for residuals autocorrelation

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	14.6790	16	0.54826
2	9.8690	16	0.87338
3	12.8793	16	0.68156
4	10.3312	16	0.84877
5	23.9040	16	0.09162
6	13.5323	16	0.63351

H0: no autocorrelation at lag order

Source: Stata17. Output

Results of table 7 indicate rejection of residuals autocorrelation up to the sixth lag, thus, model residuals are free from autocorrelation problem.

The stability of the estimated model should also be evaluated, for a model with k endogenous, there has to be a (k-r)unit eigenvalue, where r is the number of cointegration equations, the model is stable if the remaining eigenvalues are strictly less than one (Hamrit, M., & hajab, A., 2021, P. 114), the eigenvalue stability condition is displayed in table 8 below

Table .8. Eigenvalue stability condition

Eigenvalue stability condition

Eigenvalue	Modulus
1	1
1	1
1	1
.7509784 + .313099*i*	.813634
.7509784 - .313099*i*	.813634
.1091025 + .7593099*i*	.767108
.1091025 - .7593099*i*	.767108
-.13058 + .5879506*i*	.602277
-.13058 - .5879506*i*	.602277
-.4565142 + .164992*i*	.485415
-.4565142 - .164992*i*	.485415
.4418687	.441869

The VECM specification imposes 3 unit moduli

Source: Stata17. Output

As can be seen from table 8 above, the estimated model meet the stability condition.

5. CONCLUSION

The Algerian economy has long been dominated by an oil sector, which has a large share to government revenues, GDP and exports, this feature made the economy extremely vulnerable to oil price shocks, which have affected negatively the plans of investment, spending and other aspects of the economy as well. The exchange rate in Algeria has seen many different types of regimes as a response to mitigate the side effects of an economy that depends mainly on hydrocarbons revenues. it was initially pegged to French frank and then has gradually declined in value over years due to fluctuations of oil prices, the devaluation of exchange rate has progressively been done with the assistance of international monetary fund in a an attempt to diversify the economy.

In this paper, we have investigated the long run relationship via JOHANSEN cointegration technique between real effective exchange rate and its candidate fundamentals, which are productivity differentials relative to trading partners, real oil price and government spending. the study shows a highly significant relationship between them, that is, all the aforementioned fundamentals contribute jointly to determine the path of equilibrium exchange rate. On the other hand, purchasing power parity has proven to be in invalid in determining equilibrium real exchange rate; this would reflect that real exchange rate determination is not as simple as the theory might predicts especially for commodity exporting countries such as Algeria. In fact, Algeria is not highly integrated in the international market and imposes many barriers on exchange rate as well as other restriction on goods and services.

This study showed that the equilibrium exchange rate is effectively determined by the fundamentals chosen as opposed to theory, which has not have such good explanatory power. Government spending together with productivity differentials have more impact on equilibrium real exchange rate than real prices of oil. This might be explained by the fact that real prices of oil are exogenous and determined by the international market. government spending, however, is mostly owned by country and distributed between tradable and non tradable sector which could affect price channel and productivity channel.

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