# Real exchange rates and fundamentals: robustness across alternative model specifications, Algerian case(1990-2019)

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**Abstract:**

This paper explores the robustness of behavioural equilibrium exchange rate (BEER) and natural equilibrium exchange rate (NATRAX) models, focusing on the appropriate approach for the Algerian currency exchange model with Algerian dinar real bilateral rates as dependent variable. It consists, in the first step, to determinate the equilibrium real exchange rate using BEER approach developed by Macdonald (1995), and Natrex approach developed by Lim & Stein. Cointegration technics and VECM models are used in this step. In a second step, we should choose the appropriate approach by the comparison between the two approaches.

Obtained results show that the Natrex approach is advantageous in terms of degree of misalignment for the Algerian currency case. Therefore, we can conclude that it can be closer to the Algerian economic specification.

**Keywords**: Equilibrium real exchange rate, BEER, NATREX, Algerian Currency, Misalignment.

**Jel Classification Codes:**C5, E6, F31

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## 1. Introduction :

The collapse of the Bretton Woods International Monetary System in 1971 and the advent of financial globalization have led to a renewed interest in studies on the choice of an appropriate exchange rate regime. Furthermore, it's well known that the notion of equilibrium real exchange rate still open questions in developing countries, particularly in Algeria. Following the example of other countries in the world, and with a view to adopt a relevant exchange rate regime, Algeria has adopted several exchange rate policies since the creation of the Dinar in 1964, moving from a fixed to a managed floating regime. However, the issue of the misalignment of the Dinar's REER is reopening the debate on the relevance of these exchange rate policies and the appropriate analytical approaches.

In connection with the various crises conveyed by fixed exchange rate regimes, a succession of studies have been carried out to show that: fixed exchange rate regimes are generally conducive to exchange rate overvaluations resulting in real exchange rate appreciations that are detrimental to external competitiveness and the current account (Kasminsky et al. (1998), P 245-317), (Burkart and Coudert(2000), P 78-98),(Bussière and Fratzscher 2006, P 953- 973),(Rey, S. (2009),P 43-65).

The PPA approach (Cassel,1926) which is considered as a best until then to explain the REER, has been recently rejected, considering a specific characteristics of developing countries (Lim & Stein, 1995), and that was when others new approaches should be discussed.

Our empirical study focuses on the real effective exchange rate of Algerian curreny. First, we will model Algeria's currency equilibrium real exchange rate by comparing Macdonald's BEERmodel (1995) with Limand Stein's NATREX (1997) inorder to choose the appropriate model for the Algerian economy. We use cointegration technics and the vectorerror- correction model to test for the existence of along- runrelation ship between there alexchange rateandits fundamentals. Second, we'll simulate the exchange rates obtained fromthe two estimated and observed models.

This article is organized as follows. First we will present the data we will use. Second, we show the existence of a long run relationship between all I(1) borderline variables in NATREX and BEER and specify and estimate a VECM. In fine we will calculate the misaligement degree for each model, in this way we can conclude about the best approach minimizing the misalignment.

**2- Specification of the basic model for the estimation of the REER:**

A brief retrospective on the exchange rate policy in Algeria makes it possible to summarize the evolution of the Dinar exchange rate in 6 different periods:

From 1962 to 1974: a period marked by the creation of the public treasury and the central bank to move to a rigorous exchange control to put an end to the massive flight of capital.

The period from 1974 to 1985 was characterized by the state monopoly and strict exchange control, which led to the emergence of an informal exchange market.From 1986 to 1994: Algeria saw its oil revenues collapse in the face of the 1986 oil shock. External indebtedness and the devaluation of the Dinar (by about 25% in only two years) were the inevitable consequence of socialist management of the economy. The Dinar will continue to undergo another more significant devaluation between 1989 and 1991 of about 143%. As a result, a transition to a market economy proved to be an obligation, and so Algeria proceeded to liberalize in all directions, starting with financial liberalization brought in the famous law on currency and credit in April 1990. From 1995 to 2007: the objective being to stabilize the REER, a managed float regime was certainly a necessity.
In 1995 this option was adopted and the Dinar was subject to current convertibility. Thus the TCER underwent an appreciation of 10% in three years, followed by a depreciation of 12% and another real depreciation from 2002 to 2003. Generally speaking, the objective of maintaining the stability of the REER was achieved between 2005 and 2007(Benabdellah Y. 2006, pp.09-41)

From 2008 to 2014: the financial upturn due to the increase in oil revenues resulted in expansionary fiscal and monetary policies, causing a depreciation of the Dinar by 12.5%. The REER did not take long to appreciate between 2010 and 2012.

From 2014 to 2019: the monetary authorities took measures to deal with the fall in oil prices. To this effect, the depreciation of the Dinar will continue until 2016. This depreciation was quickly interrupted to resume again in 2017. In 2018, a new expansionary policy was adopted in order to support public investment and compensate for the economic slowdown.

This brief description reveals the drastic efforts made by the monetary authorities to set a long-term strategy in their exchange rate policy in the face of a rentier economy. However, an in-depth analysis with an appropriate approach will certainly improve the long-term vision. In our empirical approach, we have discarded the PPP model which has already proved its inefficiency in the case of the Algerian Dinar in the work of Cashin et al (2003), Koranchelian(2005).

The equilibrium real exchange rate is not observed but is constructed from the relationship between it and the observed or current real exchange rate (El badawi et *al*,1999, P 63*)*. To construct it, we will use the BEER model as introduced by Clark and Macdonald (1999) and the dynamic NATREX model developed by Lim and

Stein (1997). These two models have an advantage over the PPP approach in that they allow the equilibrium real exchange rate to change continuously to reflect changes in fundamentals.

We study then ature of the link between exchangerates and their fundamentals by adopting the analytic al framework of the NATREX approachonthe one hand and the BEER approachonthe other hand. Three data sources we reconsulted in order to constitute our data base: International Financial Statistics published by the IMF, the database of the World Bank and the Central Bank ofAlgeria.

The data used are annual and cover the period 1980-2019. The use of annual data provid esus with asample of 39 observations and the application of the us ualunit root tests (ADF, PP and KPSS) indicates that all our series, expressed in logarithms, are non-stationary and are integrated of order1.

**3- The long-run equilibrium real exchange rate model**

After having tested the stationary of each of the variables, we first adapt the BEER approach in order to analyze the nature of the link between the exchange rate and its fundamentals. The relationship we have chosen is as follows:

$$LTCER_t=\alpha_t+\beta_1 LPIB_t+\beta_2 LTE_t+\beta_3 LINV_t+\beta_4 IDE_t+\beta_5 LOUV_t+\varepsilon_t$$

Where $LTCER_t$ means the logarithm of the real effective exchange rate, $LPIB_t$ is the logarithm of relative productivity measuring the Balassa-Samuelson effect, $LTE_t$ represents the logarithm of the terms of trade, $LINV_t$is the logarithm of the investment rate, $IDE_t$ refers to foreign direct investment, $LOUV_t$ is the logarithm of the degree of opening, $\varepsilon_t$ measures the error term.

The coefficients $\alpha_t$ ,$\beta_i$represent the parameters to be estimated. We conduct our study of the long-run relationship within the framework of the Johansen process (1988). The first step in Johansen's method is to test the cointegration hypothesis between the real exchange rate and its fundamentals. Before performing the Johansen test, however, we determine the number of lags k by performing a VAR estimate on the exchange rate and its fundamentals.

In our estimation, the three information criteria (Akaike, Hannan and Schwartz) unanimously converge on a number of two delays (k=2).

The number of cointegration relationships is tested by the trace and maximum eigenvalue statistics provided by Johansen (1988). Obtained results are gathered in the following tables:

**Table n°1:JohansonCointegration test**

Sample (adjusted): 1983 2019

Included observations: 37 after adjustments

Trend assumption: Linear deterministic trend

Series: LTCER LPIB LOUV LTE LINV IDE

Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.812026 | 137.7915 | 95.75366 | 0.0000 |
| At most 1 * | 0.637606 | 75.94779 | 69.81889 | 0.0149 |
| At most 2 | 0.358659 | 38.39190 | 47.85613 | 0.2852 |
| At most 3 | 0.267180 | 21.95674 | 29.79707 | 0.3009 |
| At most 4 | 0.243404 | 10.45509 | 15.49471 | 0.2474 |
| At most 5 | 0.003637 | 0.134832 | 3.841466 | 0.7135 |

Trace test indicates 2 cointegratingeqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

| Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.812026 | 61.84367 | 40.07757 | 0.0001 |
| At most 1 * | 0.637606 | 37.55588 | 33.87687 | 0.0174 |
| At most 2 | 0.358659 | 16.43516 | 27.58434 | 0.6286 |
| At most 3 | 0.267180 | 11.50165 | 21.13162 | 0.5972 |
| At most 4 | 0.243404 | 10.32026 | 14.26460 | 0.1917 |
| At most 5 | 0.003637 | 0.134832 | 3.841466 | 0.7135 |

Max-eigenvalue test indicates 2 cointegratingeqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

**Source :**Eviews Software

The results presented in the tables above highlight the presence of two cointegration relationships at 5% level; After highlighting the uniqueness of the cointegrating relationship between the real exchange rate and its fundamentals, the VECM model was then estimated (See table 1 in the appendix). Inthismodel,the estimated equationoftherealexchangerateforAlgerian currencyisevenmoreexplicit in that it provides both the long-run equilibrium relationship and the mechanism ofshort-run dynamics where by there alexchangerateis brought backtoits long- run equilibrium (stationary) level by recall forces modelled by the cointegrating relationship. Expressed in first differences, the real exchange rate in this VECM model is given by:

$$DLTCER_t = -0.120645 \begin{bmatrix} LTCER_{t-1} + 0.442884 LTE_{t-1} - 0.061576 LINV_{t-1} \\ +0.26525 LOUV_{t-1} + 0.38287 IDE_{t-1} - 0.04261 LPIB_{t-1} + 5.9398 \end{bmatrix}$$

$$-0.103543 DLTCER_{t-1} - 1.560853 DLPIB_{t-1} + 0.021079 DLTE_{t-1} - 0.44527 DLINV_{t-1} + 0.24628 LOUV_{t-1} - 0.01466 DIDE_{t-1} - 0.60719 DLTCER_{t-2} - 0.8392 DLPIB_{t-2} + 0.3495 DLTE_{t-2} - 0.23216 DLINV_{t-2} + 1.01555 DLOUV_{t-2} - 0.00564 DLIDE_{t-2} - 0.0677 \ldots\ldots\ldots\ldots (1)$$

We can now rewrite, from the equation (1) the current real exchange rate for Algeria at time (t) as a model where the current realexchangerateis expressed as a non-stationary process (with a unit root), but with an error-correcting mechanism:

$$LTCER_t = LTCER_{t-1} - 0.120645[coint\,eq] - 0.103543 DLTCER_{t-1} - 1.560853 DLPIB_{t-1} + 0.021079 DLTE_{t-1} - 0.44527 DLINV_{t-1} + 0.24628 LOUV_{t-1} - 0.01466 DIDE_{t-1} - 0.60719 DLTCER_{t-2} - 0.8392 DLPIB_{t-2} + 0.3495 DLTE_{t-2} - 0.23216 DLINV_{t-2} + 1.01555 DLOUV_{t-2} - 0.00564 DLIDE_{t-2} - 0.0677$$

The coefficient in this equation is negative; this is acondition *sine qua non* for the specification with VECM to bevalidated. It is inter preted as the speed of adjustment of the real exchange rate towards its long-run equilibrium level. The speed of adjustment is$\alpha = -0.120645$. The deviation from the equilibrium level will be resorbed by the system at this speed. Algeria's current real exchange rate attime(t) is a function of three components. The first is the real exchange rate of the previous year (t − 1), a variable to which the model associates a unit root in accordance with the spirit of the VECM specification. The second component concerns the cointegrating relationship or error-correcting mechanism. The last concerns the relation ships of the short-run dynamics,whichare transitory shocks. When the deviation from equilibrium is completely resorbed, corrected by the error-correcting mechanism that describes the long-run dynamics of the model. The long run relationship resulting from the cointegration relationship is therefore written asfollows:

$$LTCER_t = 0.44288 LTE_{t-1} - 0.061576 LINV_{t-1} + 0.38287 IDE_{t-1} + 0.26525 LOUV_{t-1} - 0.042612 LPIB_{t-1} + 05.9398 + \varepsilon_t$$

After highlighting the long-run relationship between the real effective exchange rate and its fundamentals, we estimate the short-run adjustment model only with significant variables:

$$DLTCER_t = -0.120645 - 0.6071 DLTCER_{t-2} - 0.04452 DLINV_{t-1} + 0.0155 DLOUV_{t-2} + \varepsilon_{t-1}$$

We can say that the coefficients of the different variables that exert short-run effects on the real exchange rate, which are termed transitory, are generally less robust than the coefficients of the long-run relationship. In the short run, onlythe real exchange rate and trade openness lagged by two periods, and domestic investment lagged by one period, have relatively significant coefficients of (0.6071), (0.0155) and (0.04452) respectively. The other variables in the model (foreign direct investment, terms of trade, productivity) all have insignificant effects on the real exchange rate in the shortrun.

The variables, domestic investment and gross domestic product have an appreciation effect on the real exchange rate (a decline). On the other hand, the terms of trade, foreign direct investment and trade openness have a real exchange rate depreciation effect (an increase) in the long run.

After estimating the equilibrium real exchange rate model using the BEER approach, we then proceeded to estimate the second model, which is base don Lim and Stein (1997) and incorporates the work of Edwards (1988) and Balassa (1964) in the NATREX model. They take into account the impact of real shocks on the equilibrium level of the real exchange rate, as noted in the paper. z = (PIB,TE,I,EPAR)or PIB: Productivity as represented by GDP per capita;TE: The terms of trade; I:The world interest rate; it is calculated on the basis of rates on government securities at ten years of the ten partners weighted by their respective weights; EPAR: Gross savings as a percentage of GDP, it represents a temporal preference that is the inverse of domestic consumption. Gross savings is calculated as gross national income minus total consumption plus net transfers.

After testing the stationary of each of the variables, we adapt the NATREX approach to analyze the nature of the link between the exchange rate and its fundamentals. The relationship we have chosen is as follows:

$$LTCER_t = \alpha_t + \beta_1 LPIB_t + \beta_2 LTE_t + \beta_3 I_t + \beta_4 EPAR_t + \varepsilon_t$$

Before performing the Johan sentest, we should determine the number of lags (k). Inour estimation, the three criteria unanimously converge to a number of two lags (k=2).

The number of cointegration relationships is tested by the trace and maximum eigen value statistics provided by Johans en(1988),There sultsare presented in the following tables:

**Table n°2: Trace and maximum eigenvalue Test**

Unrestricted Cointegration Rank Test (Trace)

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.819269 | 131.4522 | 69.81889 | 0.0000 |
| At most 1 * | 0.608259 | 69.86531 | 47.85613 | 0.0001 |
| At most 2 * | 0.436398 | 36.12777 | 29.79707 | 0.0082 |
| At most 3 | 0.327189 | 15.48512 | 15.49471 | 0.0502 |
| At most 4 | 0.033285 | 1.218639 | 3.841466 | 0.2696 |

Trace test indicates 3 cointegratingeqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

| Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.819269 | 61.58692 | 33.87687 | 0.0000 |
| At most 1 * | 0.608259 | 33.73753 | 27.58434 | 0.0071 |
| At most 2 | 0.436398 | 20.64266 | 21.13162 | 0.0584 |
| At most 3 * | 0.327189 | 14.26648 | 14.26460 | 0.0500 |
| At most 4 | 0.033285 | 1.218639 | 3.841466 | 0.2696 |

Max-eigenvalue test indicates 2 cointegratingeqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

**Source :**Eviews Software

Obtained results, presented in the tables above, reveal the presence of two cointegration relationships at the 5% level. After demonstrating the uniqueness of the cointegrating relationship between the real exchange rate and its fundamentals, Johansen's (1988) method estimates the cointegrating equation representing the long-run relationship (See table 2 in the appendix).

The estimated equations obtained in table *(2) in the* appendix, show that the adjustment coefficient is negative and statistically significant (-0.38), which proofs the existence of an error correction mechanism and consequently a long-run relationship between the variables, the value of this coefficient is 0.38,indicating a misalignment of 38% of the exchange rate from itsequilibrium.

The long run relationship resulting from the cointegration relationship is, therefore written as follows:

$$LTCER_t = 0.089781 LTE_{t-1} - 0.051811 LPIB_{t-1} + 0.305592 LEPAR_{t-1} + 0.2362 I_{t-1} - 1.4143 + \varepsilon_t$$

All the variables (the terms of trade, productivity, the savings rate, and the world interest rate) relating to the determination of the equilibrium real exchange rate are significantly different from zero. The signs of the coefficients of the variables (except for the world interest rate) are different from those of the Lim and Stein (1997) model applied to the Australiandata, Lim,G, Stein,L. (1995). Indeed, Lim and Stein (1997) assume that an increase in the savings ratio has direct and indirect effects on the relative price of non-tradable goods; they assume that the indirect effects of an increase in savings would dominate the direct effect, and that this increase in the savings ratio would lead to an appreciation of the real exchange rate. However, our results show that, for the Algerian economy case, it is the direct effect that is dominant and, consequently, an increase in long-run domestic savings will lead to a depreciation of the equilibrium real exchange rate.

With regard to the terms of trade, their improvement leads to an appreciation of there alexchangerate in the NATREX modelof Lim and Stein(1997). However, according to our results, an improvement in the terms of trade depreciates the Algerian currency (DA). This contradictory result is also valid for productivity; productivity has also a positive effect on the real exchange rate. A 1% in crease in (LPIB) would lead to an appreciation of there alexchangerate of about 0.010%. This result corroborate the Blassa-Samuelson effect, which is at odds with the Lim and Stein's obtained results in the case of a small openeconomy.

We can estimate now the short-run adjustment model only with the significant variables as follows:

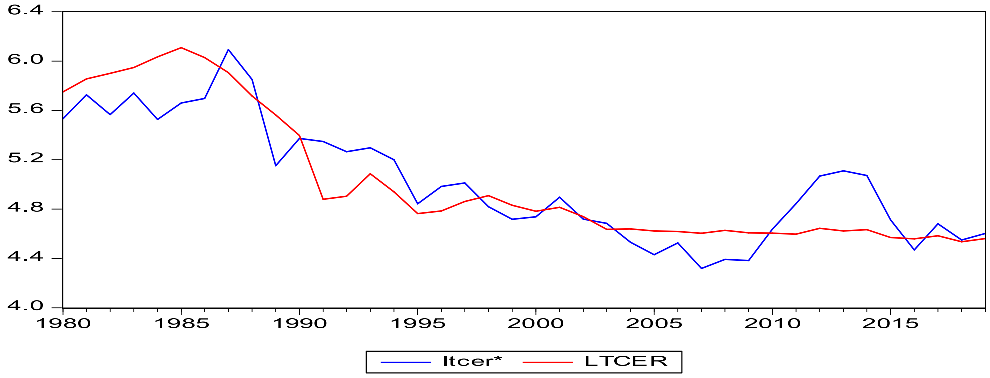
$$DLTCER_t = 0.005305 LEPAR_{t-1} + 0.03787 LTE_{t-1} - 0.00353 LTCER_{t-2} + \varepsilon_t$$

According to the model estimated above, the **savings** variable has a negative effect on the exchange rate in the short run, a 1% increase in savings can depreciate the exchange rate by 0.0053% and does not seem to change its effect over time (a depreciation effect in the short and long run). The other significant variable is the terms-of-trade variable that negatively affects the exchange rate in the short run, so a 1% in creasein the terms of trade lead stoade preciation of the exchange rate by0.037%.

**4- Misalignment calculation and Validation of the estimated models:**

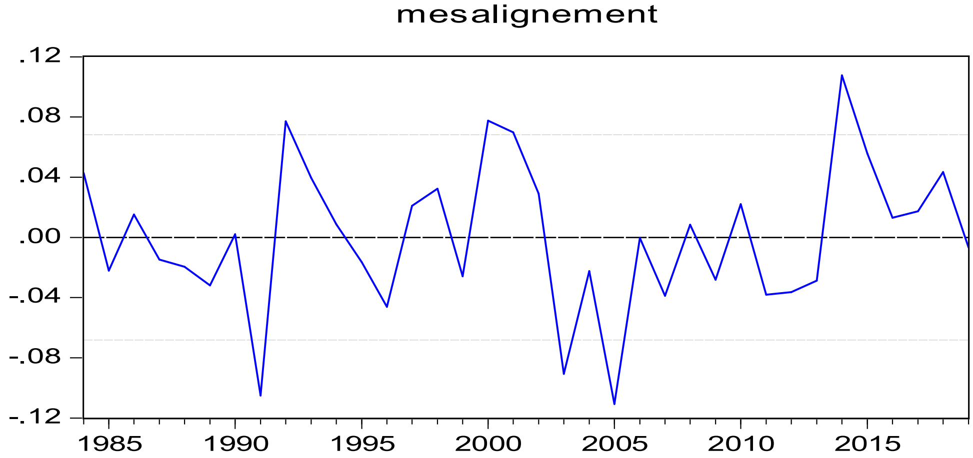
After estimating the two VEC Models, using BEER and NATREX Approaches, and discussing the effects of fundamentals on the real exchange rate, we should calculate the misalignement and deduct the corresponding graphs (Figure n° 01, Figure N° 03) representing the mesalignments of the Algerian Dinar with respect to its long-run equilibrium value. In Figures 01 and 02, the LTCER* curve represents the observed real effective exchange rate of the Algerian dinar (quoted to certain), according to the World Bank database. The LTCER curve corresponds to the equilibrium real exchange rate that we calculated following the model of Macdonald (1999) and Lim and Stein (1997).

**Fig N°1 : Evolution of e real exchange rate of the Algerian Dinar(LTCER*) around of its equilibrium value (LTCER) Using BEER Approach.**



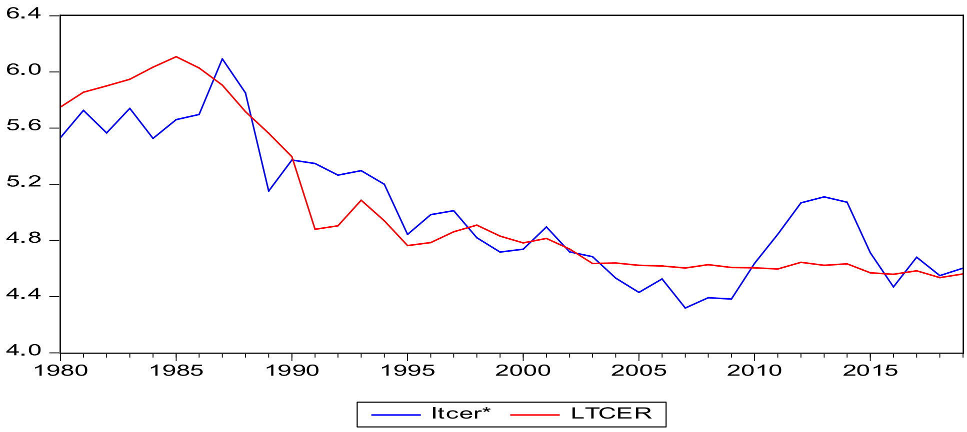

**Source :**Eviews Software

**Fig N°02 : Misalignement according to BEER Approach**



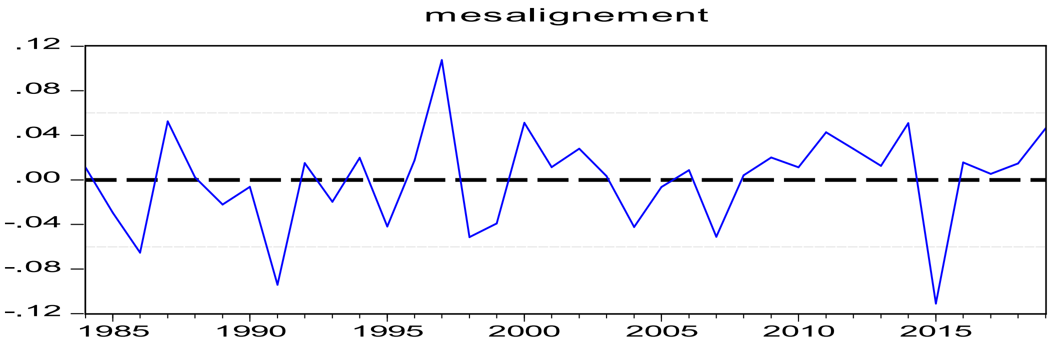

**Source :**Eviews Software

**Fig N°3 : Evolution of e real exchange rate of the Algerian Dinar(LTCER*) around of its equilibrium value (LTCER) using NATREX Approach**




**Source :**Eviews Software

**Fig04 : Misalignement according to NATREX Approach**




**Source :**Eviews Software

In Figures 01, 02, 03 and 04, the LTCER* curve represents the observed real effective exchange rate of the Algerian dinar (quoted to certain), according to the World Bank database. The LTCER curve corresponds to the equilibrium real exchange rate that we calculated following the model of Macdonald (1999) and Lim and Stein (1997).

From the Figure 01 and 03, We can clearly see that the LTCER* is very close to LTCER, which can be explained by the minimizing of the misalignment better than the Figure 01 when we use BEER model.

The specifications obtained in the BEER and NATREX models are globally satisfactory. The models explain almost 89.33% and 86.08 of the observed variability in the real exchange rate, respectively. Moreover, the residuals of the VEC models are stationary. With respect to robustness tests, the null hypothesis is accepted in all performed tests. Consequently, it can be concluded that the residuals are indeed white noise and meet the model's conditions of validity, namely the absence of autocorrelation, the existence of Normality and Homoscedasticity (Tests results are presented in the appendix).

**5. Conclusion:**

The interest of such a study is to bring additional elements to the debate on the appropriateness of an exchange rate regime**.** This study, carried out for the Algerian currency case, reveal the importance of choosing the right analysis approach.

From a theoretical point of view, the NATREX approach presents, compared to the BEER approach, an analysis of the dynamics of real exchange rates and the processes of transition to medium- and long-run equilibrium, furthermore and from an econometric point of view, NATREX offers the possibility of estimating a structural shape. On the one hand, this makes possible to verify the relevance of behavioral relationships, on the other hand, medium-run and long run NATREXs can be deduced from the explicit consideration of equilibrium conditions (equations). The obtained results, from the Algerian case study show clearly and demonstrates these advantages. The misalignment of the exchange rate of Algerian Dinar is lowered in NATREX model, hence its adequacy with the observed data.

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## 7. Appendices :

**Table N° 01 VECM (BEER Approach)**

Vector Error Correction Estimates

Date: 03/23/20 Time: 17:27

Sample (adjusted): 1983 2019

Included observations: 37 after adjustments

Standard errors in ( ) & t-statistics in [ ]

| CointegratingEq: | CointEq1 | CointEq2 |
|---|---|---|
| LTCER(-1) | 1.000000 | 0.000000 |
| LPIB(-1) | 0.000000 | 1.000000 |
| LTE(-1) | -194.9533 | -85.55995 |
| | (44.7662) | (19.3699) |

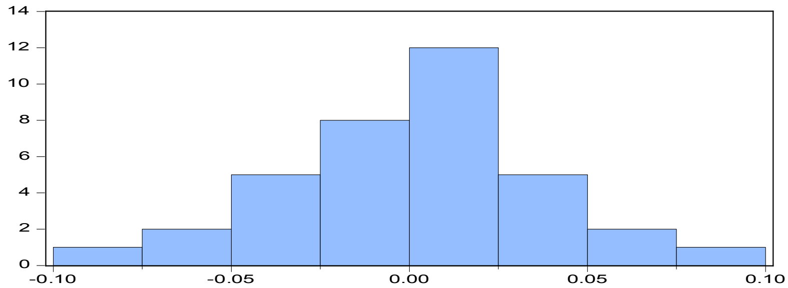
| | | |
|---|---|---|
| | [-4.35492] | [-4.41716] |
| LINV(-1) | 292.1764 | 128.0323 |
| | (86.0947) | (37.2524) |
| | [ 3.39366] | [ 3.43689] |
| LOUV(-1) | 223.7162 | 94.54014 |
| | (57.1110) | (24.7114) |
| | [ 3.91722] | [ 3.82577] |
| IDE(-1) | -56.16852 | -24.98537 |
| | (24.0857) | (10.4217) |
| | [-2.33203] | [-2.39745] |
| C | -949.9477 | -408.0904 |

| Error Correction: | D(LTCER) | D(LPIB) | D(LTE) | D(LINV) | D(LOUV) | D(IDE) |
|---|---|---|---|---|---|---|
| CointEq1 | -0.120645 | -0.042612 | 0.442884 | -0.061576 | 0.265255 | 0.382878 |
| | (0.06124) | (0.01934) | (0.20068) | (0.08192) | (0.11183) | (0.37668) |
| | [-1.97002] | [-2.20373] | [ 2.20692] | [-0.75166] | [ 2.37188] | [ 1.01644] |
| CointEq2 | 0.054032 | 0.018592 | -0.190729 | 0.025604 | -0.115154 | -0.163270 |
| | (0.02652) | (0.00837) | (0.08689) | (0.03547) | (0.04842) | (0.16310) |
| | [ 2.03761] | [ 2.22055] | [-2.19495] | [ 0.72183] | [-2.37804] | [-1.00101] |
| D(LTCER(-2)) | -0.607199 | -0.026207 | 0.485590 | 0.001724 | 0.187980 | 1.119950 |
| | (0.14807) | (0.04675) | (0.48522) | (0.19808) | (0.27040) | (0.91079) |
| | [-4.10063] | [-0.56054] | [ 1.00075] | [ 0.00870] | [ 0.69518] | [ 1.22965] |
| D(LPIB(-1)) | 1.560853 | 0.016161 | 6.600836 | -1.604123 | 1.958960 | 3.173137 |
| | (0.82119) | (0.25929) | (2.69094) | (1.09848) | (1.49960) | (5.05102) |
| | [ 1.90073] | [ 0.06233] | [ 2.45298] | [-1.46031] | [ 1.30633] | [ 0.62822] |
| D(LPIB(-2)) | -0.839246 | 0.072486 | 0.269445 | -0.003472 | 0.089051 | -2.821539 |
| | (0.58244) | (0.18390) | (1.90859) | (0.77911) | (1.06361) | (3.58251) |
| | [-1.44092] | [ 0.39416] | [ 0.14117] | [-0.00446] | [ 0.08373] | [-0.78759] |
| D(LTE(-1)) | -0.021079 | -0.097607 | 1.278323 | -0.088068 | 0.771318 | 2.016227 |
| | (0.22723) | (0.07175) | (0.74462) | (0.30396) | (0.41496) | (1.39768) |
| | [-0.09276] | [-1.36042] | [ 1.71675] | [-0.28973] | [ 1.85879] | [ 1.44255] |
| D(LTE(-2)) | 0.349542 | -0.030357 | 1.715948 | -0.309312 | 0.633449 | 1.297607 |
| | (0.23360) | (0.07376) | (0.76549) | (0.31248) | (0.42659) | (1.43687) |
| | [ 1.49630] | [-0.41157] | [ 2.24162] | [-0.98985] | [ 1.48491] | [ 0.90308] |
| D(LINV(-1)) | -0.445272 | -0.050631 | 0.487313 | 0.242709 | 0.634243 | -0.969083 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.20223) | (0.06385) | (0.66269) | (0.27052) | (0.36930) | (1.24390) |
| | [-2.20179] | [-0.79292] | [ 0.73535] | [ 0.89719] | [ 1.71741] | [-0.77907] |
| D(LINV(-2)) | -0.232169 | -0.112322 | 1.271746 | -0.321553 | 0.495103 | -0.029166 |
| | (0.23008) | (0.07265) | (0.75396) | (0.30777) | (0.42016) | (1.41521) |
| | [-1.00907] | [-1.54612] | [ 1.68677] | [-1.04477] | [ 1.17837] | [-0.02061] |
| D(LOUV(-1)) | -0.246280 | 0.117681 | -0.407101 | 0.277825 | -0.164158 | -1.394236 |
| | (0.25114) | (0.07930) | (0.82296) | (0.33594) | (0.45861) | (1.54473) |
| | [-0.98065] | [ 1.48407] | [-0.49468] | [ 0.82700] | [-0.35794] | [-0.90258] |
| D(LOUV(-2)) | -1.015551 | -0.034601 | -1.766294 | 0.469774 | -0.698193 | -0.502858 |
| | (0.27777) | (0.08770) | (0.91023) | (0.37157) | (0.50725) | (1.70854) |
| | [-3.65608] | [-0.39452] | [-1.94050] | [ 1.26431] | [-1.37644] | [-0.29432] |
| D(IDE(-1)) | -0.014661 | -0.008064 | 0.021965 | -0.041598 | 0.020799 | -0.138891 |
| | (0.03314) | (0.01046) | (0.10859) | (0.04433) | (0.06052) | (0.20383) |
| | [-0.44241] | [-0.77066] | [ 0.20228] | [-0.93839] | [ 0.34369] | [-0.68140] |
| D(IDE(-2)) | -0.005641 | 0.002141 | 0.024237 | -0.010065 | -0.000479 | -0.080525 |
| | (0.03054) | (0.00964) | (0.10009) | (0.04086) | (0.05578) | (0.18787) |
| | [-0.18470] | [ 0.22198] | [ 0.24216] | [-0.24634] | [-0.00859] | [-0.42861] |
| C | -0.067700 | 0.005283 | -0.065602 | 0.032227 | -0.017570 | 0.066538 |
| | (0.01690) | (0.00534) | (0.05540) | (0.02261) | (0.03087) | (0.10398) |
| | [-4.00478] | [ 0.98984] | [-1.18426] | [ 1.42516] | [-0.56917] | [ 0.63992] |
| R-squared | 0.893356 | 0.744873 | 0.764293 | 0.709820 | 0.477691 | 0.574672 |
| Adj. R-squared | 0.751163 | 0.404703 | 0.450017 | 0.322912 | -0.218722 | 0.007567 |
| Sum sq. resids | 0.049897 | 0.006963 | 0.083309 | 1.854768 | 0.851178 | 0.214915 |
| S.E. equation | 0.057675 | 0.021546 | 0.074525 | 0.351641 | 0.238213 | 0.119698 |
| F-statistic | 6.282719 | 2.189711 | 2.431919 | 1.834599 | 0.685930 | 1.013344 |
| Log likelihood | 67.38202 | 102.8295 | 58.15503 | 2.301876 | 16.32196 | 41.09675 |
| Akaike AIC | -2.576779 | -4.546083 | -2.064168 | 1.038785 | 0.259891 | -1.116486 |
| Schwarz SC | -1.653060 | -3.622363 | -1.140449 | 1.962504 | 1.183610 | -0.192767 |
| Mean dependent | -0.038536 | 0.006992 | 0.004180 | 0.020279 | 0.001735 | 0.001841 |
| S.D. dependent | 0.115620 | 0.027925 | 0.100491 | 0.427343 | 0.215781 | 0.120154 |

| | |
|---|---|
| Determinant resid covariance (dof adj.) | 1.23E-14 |
| Determinant resid covariance | 6.43E-17 |
| Log likelihood | 364.5951 |
| Akaike information criterion | -12.58862 |
| Schwarz criterion | -6.518460 |

### Normality Test:




Series: Residuals
Sample 1984 2019
Observations 36

| | |
|---|---|
| Mean | -6.35e-15 |
| Median | 0.003348 |
| Maximum | 0.093450 |
| Minimum | -0.094244 |
| Std. Dev. | 0.037757 |
| Skewness | -0.166173 |
| Kurtosis | 3.428177 |
| Jarque-Bera | 0.440684 |
| Probability | 0.802244 |

### Autocorrelation Test:

Breusch-Godfrey Serial Correlation LM Test:

| | | | |
|---|---|---|---|
| F-statistic | 0.751243 | Prob. F(3,12) | 0.5424 |
| Obs*R-squared | 5.692142 | Prob. Chi-Square(3) | 0.1276 |

Test Equation:

### Homoscedasticity Test:

Heteroskedasticity Test: Breusch-Pagan-Godfrey

| | | | |
|---|---|---|---|
| F-statistic | 1.035320 | Prob. F(24,11) | 0.4992 |
| Obs*R-squared | 24.95326 | Prob. Chi-Square(24) | 0.4083 |
| Scaled explained SS | 5.259629 | Prob. Chi-Square(24) | 1.0000 |

### Table N°2 VECM (NATREX Approach)

Vector Error Correction Estimates

Date: 03/22/20 Time: 16:39

Sample (adjusted): 1984 2019

Included observations: 36 after adjustments

Standard errors in ( ) & t-statistics in [ ]

| CointegratingEq: | CointEq1 | CointEq2 |
|---|---|---|
| LTCER(-1) | 1.000000 | 0.000000 |
| LI(-1) | 0.000000 | 1.000000 |
| LPIB(-1) | 7.514011 | -4.100879 |
| | (1.34730) | (1.26232) |
| | [ 5.57707] | [-3.24868] |

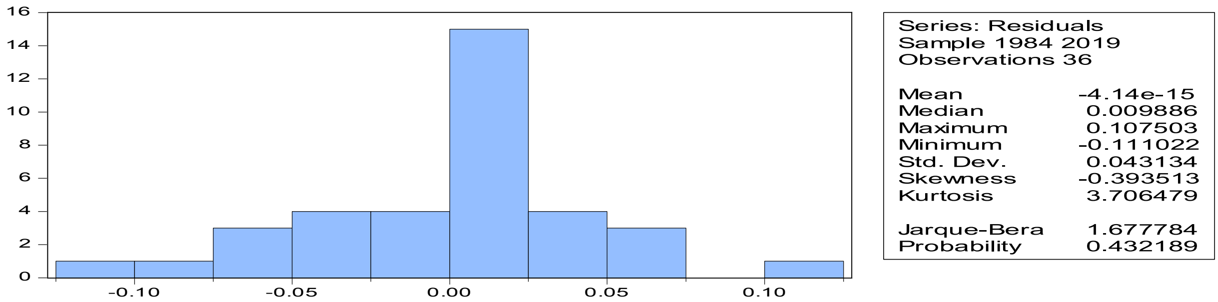
| | | | | | |
|---|---|---|---|---|---|
| LTE(-1) | -2.922188 | 2.522306 | | | |
| | (0.44551) | (0.41741) | | | |
| | [-6.55913] | [ 6.04270] | | | |
| LEPAR(-1) | 2.821365 | -3.149596 | | | |
| | (0.61472) | (0.57594) | | | |
| | [ 4.58970] | [-5.46859] | | | |
| C | -63.14382 | 31.09521 | | | |
| Error Correction: | D(LTCER) | D(LI) | D(LPIB) | D(LTE) | D(LEPAR) |
| CointEq1 | -0.389342 | 0.236212 | -0.051811 | 0.089781 | 0.305592 |
| | (0.04969) | (0.08832) | (0.02652) | (0.27449) | (0.13602) |
| | [-5.58671] | [2.67438] | [-1.95342] | [ 0.32709] | [ 2.24665] |
| CointEq2 | -0.323598 | -0.339288 | -0.035084 | -0.015646 | 0.291881 |
| | (0.08147) | (0.10325) | (0.03101) | (0.32087) | (0.15901) |
| | [-3.97207] | [-3.28606] | [-1.13155] | [-0.04876] | [ 1.83563] |
| D(LTCER(-1)) | 0.603177 | -0.360813 | -0.102863 | -0.625410 | -0.680278 |
| | (0.22040) | (0.27933) | (0.08388) | (0.86809) | (0.43018) |
| | [ 2.73671] | [-1.29170] | [-1.22628] | [-0.72045] | [-1.58139] |
| D(LTCER(-2)) | -0.353570 | 0.532737 | 0.083553 | -0.300858 | -0.164074 |
| | (0.17350) | (0.21989) | (0.06603) | (0.68334) | (0.33863) |
| | [-2.03789] | [ 2.42279] | [ 1.26537] | [-0.44027] | [-0.48452] |
| D(LTCER(-3)) | 0.713762 | -0.560081 | 0.113237 | -0.547832 | -0.551868 |
| | (0.20363) | (0.25808) | (0.07750) | (0.80203) | (0.39744) |
| | [ 3.50516] | [-2.17021] | [ 1.46114] | [-0.68306] | [-1.38854] |
| D(LI(-1)) | 0.080587 | 0.199953 | -0.017927 | -0.073855 | 0.038986 |
| | (0.10852) | (0.13753) | (0.04130) | (0.42742) | (0.21180) |
| | [ 0.74261] | [ 1.45385] | [-0.43406] | [-0.17279] | [ 0.18406] |
| D(LI(-2)) | -0.118009 | 0.065722 | 0.006791 | -0.370401 | -0.333223 |
| | (0.11360) | (0.14397) | (0.04323) | (0.44742) | (0.22172) |
| | [-1.03883] | [ 0.45649] | [ 0.15707] | [-0.82786] | [-1.50291] |
| D(LI(-3)) | 0.574109 | -0.247814 | 0.038887 | -0.442135 | -0.443490 |
| | (0.12219) | (0.15486) | (0.04650) | (0.48126) | (0.23849) |
| | [ 4.69854] | [-1.60026] | [ 0.83622] | [-0.91871] | [-1.85961] |

| | | | | | |
|---|---|---|---|---|---|
| D(LPIB(-1)) | 1.155076 | -0.145604 | 0.375915 | 2.608750 | 1.601630 |
| | (0.65786) | (0.83375) | (0.25037) | (2.59107) | (1.28400) |
| | [ 1.75581] | [-0.17464] | [ 1.50142] | [ 1.00682] | [ 1.24738] |
| D(LPIB(-2)) | -0.037077 | -2.446968 | 0.258599 | -1.252071 | 0.442294 |
| | (0.66223) | (0.83929) | (0.25204) | (2.60829) | (1.29253) |
| | [-0.05599] | [-2.91551] | [ 1.02604] | [-0.48003] | [ 0.34219] |
| D(LPIB(-3)) | 0.733631 | -1.493890 | -0.120903 | -1.347696 | -1.235862 |
| | (0.68910) | (0.87334) | (0.26226) | (2.71410) | (1.34497) |
| | [ 1.06463] | [-1.71055] | [-0.46100] | [-0.49655] | [-0.91888] |
| D(LTE(-1)) | -0.378771 | 0.139661 | 0.022468 | -0.039068 | 0.000714 |
| | (0.13726) | (0.17395) | (0.05224) | (0.54060) | (0.26789) |
| | [-2.75959] | [ 0.80286] | [ 0.43011] | [-0.07227] | [ 0.00266] |
| D(LTE(-2)) | -0.027450 | -0.066390 | -0.004506 | 0.557666 | 0.352459 |
| | (0.15088) | (0.19122) | (0.05742) | (0.59425) | (0.29448) |
| | [-0.18193] | [-0.34720] | [-0.07848] | [ 0.93844] | [ 1.19690] |
| D(LTE(-3)) | -0.580515 | -0.083984 | -0.110940 | 0.066722 | 0.208548 |
| | (0.14359) | (0.18199) | (0.05465) | (0.56557) | (0.28026) |
| | [-4.04274] | [-0.46148] | [-2.03000] | [ 0.11797] | [ 0.74411] |
| D(LEPAR(-1)) | 0.530591 | -0.727859 | -0.045155 | 0.317020 | 0.152382 |
| | (0.24707) | (0.31313) | (0.09403) | (0.97311) | (0.48222) |
| | [ 2.14756] | [-2.32449] | [-0.48022] | [ 0.32578] | [ 0.31600] |
| D(LEPAR(-2)) | -0.242726 | -0.174450 | 0.030218 | -0.918454 | -0.332624 |
| | (0.27160) | (0.34421) | (0.10337) | (1.06972) | (0.53010) |
| | [-0.89370] | [-0.50681] | [ 0.29234] | [-0.85859] | [-0.62748] |
| D(LEPAR(-3)) | 0.648714 | -0.393215 | 0.159219 | -0.430629 | -0.352092 |
| | (0.24945) | (0.31614) | (0.09494) | (0.98248) | (0.48687) |
| | [ 2.60061] | [-1.24379] | [ 1.67712] | [-0.43831] | [-0.72318] |
| C | -0.032842 | 0.046427 | 0.005162 | -0.026801 | -0.037438 |
| | (0.02381) | (0.03017) | (0.00906) | (0.09377) | (0.04647) |
| | [-1.37949] | [ 1.53868] | [ 0.56969] | [-0.28582] | [-0.80569] |
| R-squared | 0.860822 | 0.874645 | 0.654415 | 0.380127 | 0.634730 |
| Adj. R-squared | 0.729376 | 0.756254 | 0.328030 | -0.205309 | 0.289753 |
| Sum sq. resids | 0.065118 | 0.104595 | 0.009432 | 1.010172 | 0.248065 |

| | | | | | |
|---|---|---|---|---|---|
| S.E. equation | 0.060147 | 0.076229 | 0.022891 | 0.236898 | 0.117394 |
| F-statistic | 6.548861 | 7.387760 | 2.005037 | 0.649305 | 1.839920 |
| Log likelihood | 62.58943 | 54.05943 | 97.36692 | 13.23938 | 38.51468 |
| Akaike AIC | -2.477191 | -2.003302 | -4.409273 | 0.264479 | -1.139704 |
| Schwarz SC | -1.685431 | -1.211542 | -3.617514 | 1.056238 | -0.347945 |
| Mean dependent | -0.038536 | 0.027245 | 0.006992 | 0.001735 | -0.000990 |
| S.D. dependent | 0.115620 | 0.154401 | 0.027925 | 0.215781 | 0.139297 |

| | |
|---|---|
| Determinant resid covariance (dof adj.) | 5.45E-13 |
| Determinant resid covariance | 1.70E-14 |
| Log likelihood | 315.2443 |
| Akaike information criterion | -11.95802 |
| Schwarz criterion | -7.559356 |

**Normality Test:**




**Autocorrelation Test:**

Breusch-Godfrey Serial Correlation LM Test:

| | | | |
|---|---|---|---|
| F-statistic | 1.322904 | Prob. F(3,15) | 0.3039 |
| Obs*R-squared | 7.532070 | Prob. Chi-Square(3) | 0.0567 |

**Homoscedasticity Test:**

Heteroskedasticity Test: Breusch-Pagan-Godfrey

| | | | |
|---|---|---|---|
| F-statistic | 0.677180 | Prob. F(20,15) | 0.7949 |
| Obs*R-squared | 17.08158 | Prob. Chi-Square(20) | 0.6477 |
| Scaled explained SS | 5.778866 | Prob. Chi-Square(20) | 0.9992 |